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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
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The American Foundry Industry under the Defence Programme

The following article has been specially written for this page by Mr. Oliver Smalley, O.B.E., the Chairman of the International Meehanite Metal Company of Pittsburgh, U.S.A.

The American nation is now irrevocably committed to the defence of the democracies at whatever risk and at whatever cost. The average citizen realises that the cost will be tremendous and that it must be met out of current real income. All industry, including the foundry industry, recognises that it must expand production to a point where total capacity and output will be several times in excess of that of entire Continental Europe.

Production for civilian needs is being curtailed in some lines and priorities are being instituted. Indication of shortages have developed in such non-ferrous metals as aluminium, zinc, copper, tin and nickel, and is accompanied by serious shortages of alloys, pig-iron, scrap and coke. Steel production, however, continues at top speed, and is expected to reach a total of about ninety-three million tons for this year.

A shortage of shipping is causing serious concern and is getting active attention. All available naval shipyards are operating at capacity and new shipyards are under construction. Both rail and motor truck transportation facilities are working at capacity, and new engines, rolling stock and trucks are in demand.

Plans call for the American Defence Programme to reach maximum activity in 1942, and naturally this has resulted in heavy demands on the foundry industry which, as a whole, is most anxious to support the programme to the limit. Fortunately, remarkable progress in practices and products has been made since 1918, and the foundry industry of 1941 is in a position to render much broader, all-round service than was possible twenty years ago.

In order to obtain maximum output, new buildings are being erected, disused foundries are being reopened, and present plants are being brought up to the highest operating efficiency by the installation of new, modern equipment. For example, the Cincinnati Milling Machine Company at Cincinnati have erected, and are now operating, one of the largest and most modern foundries in the world.

From the foundry standpoint, the raw material problem in many cases has become acute. This is caused primarily by the consumption of much of the available pig-iron and steel scrap by the steel producing plants. However, the trade associations, representing the steel, malleable and grey iron foundries are very active in their efforts to see to it that their members are not unduly hampered in their work of producing the wide variety of castings which play such an important part in the construction of all types of war machinery.

Groups, as well as individual foundrymen, have gone to great lengths to acquaint the army and navy with the progress which the foundry industry has made and with the better products it is now able to produce. A large amount of data dealing with the availability of castings and the functions which they are able to serve, have been provided to Government agencies. In some cases, however, it has been difficult to get a fair trial for their products in competition with forgings, welded construction, and the like.

Steel foundries producing miscellaneous castings are currently operating at about 85 per cent. capacity. The use of steel castings as armour plate for tanks is increasing rapidly, and reports indicate that seven foundries out of nine are producing cast turrets and cast hulls to be used in medium and heavy tanks for both Great Britain and the United States. A number of foundries are also producing cast steel shells.

Although not greatly involved in ordnance work, the malleable iron foundries are also operating at almost capacity. Malleable castings are finding applications on all motorised equipment and in various other special applications. Shells of pearlitic malleable are being produced for foreign Governments and are being experimented with in this country.

The grey iron industry is exceptionally busy and is operating at capacity, where it is producing tremendous volumes for the marine engine and machine tool fields. Regular and educational orders for shells and ammunition parts are being cast in grey iron for both the British and the American Governments.

Considerable defence work is being done by the non-ferrous foundries, especially the aluminium, bronze and magnesium plants which specialise in aircraft castings.

(*Continued overleaf.*)

Notes from the Branches

London Branch.—Mr. G. H. Meigh, of Meigh High Tensile Alloys, Limited, of Cheltenham, is to read a Paper on "Aluminium Bronze" at 3 p.m., on April 5, at Charing Cross Hotel. It is expected that monthly meetings will be arranged throughout the spring and summer months.

East Anglian Section.—The Annual General Meeting was held in Ipswich on March 15. Mr. H. H. Shepherd presided, and Mr. J. L. Francis presented the following report.

The Institute has now experienced a full 12 months of activities modified to suit the conditions imposed by war. In spite of difficulties and restrictions, most branches have carried out a programme, and made every effort to keep things going in their respective areas. It is satisfactory to be able to report that the East Anglian Section has not been lacking in such efforts. Since the last Annual General Meeting 12 applications for membership of the Section have been received, making the total membership 63 with 1 member firm.

Instead of the usual session of lectures running from October to March the programme commenced in the latter month with a works visit and the Annual General Meeting. Subsequently four other meetings were held, extending throughout the summer to July. Thanks and appreciation are here recorded to all those who in various ways helped to make this programme possible, particularly to the authors of Papers, who made time to write and present them under pressure of extra work and often under uncomfortable conditions of travel.

Another very noteworthy effort from the East Anglian Section must receive mention. Three of its members had the honour of presenting Papers to the Annual Conference, for which two of them were awarded the Diploma of the Institute, the third member concerned having had the Diploma awarded for a previous Paper. On the whole it is thought that the activity of the Section during the past 12 months has been such as would reflect credit, even in normal times.

Although the purpose of this Report is to review the past and not anticipate the future, it may perhaps be mentioned that there is every prospect of arranging another lecture programme for the current session, similar to the one recalled here. So it is hoped that members will take pride and encouragement from satisfactory achievements of the past and by their efforts and attendance at the meetings arranged, ensure that the future may be no less satisfactory.

The following officers were elected to serve for the next twelve months:—

President: Mr. G. H. Hall.

Vice-Presidents: Mr. C. J. Lake and Mr. F. Tibbenham.

Honorary Secretary: Mr. J. L. Francis.

The diplomas won by Mr. E. W. Dowson and Mr. J. L. Francis were presented by the retiring President. A Paper on "Some Precautions to be taken in the Production of Sound Malleable Castings," by Mr. V. Wood, was then presented and discussed.

Lancashire Branch.—The Annual Meeting of the Lancashire Branch will be held in the Engineers' Club, Albert Square, Manchester, on April 5, at 3 p.m. The R. A. Jones Medal of Merit is to be presented to Mr. A. Sutcliffe, and the Diploma of the Institute to Mr. A. Hopwood for his Paper to the London Branch. The meeting will be followed by an ordinary meeting devoted to the discussion of foundry problems.

Middlesbrough Branch.—The Annual General Meeting of the Branch was held in Cleveland Technical Institute on March 15, 1941, Mr. David R. Kinnel presiding. The Hon. Secretary, Mr. J. K. Smithson, in a brief report said that the membership had been well maintained during the year, and that subscriptions received showed a slight increase over 1939. Five meetings had been held during the winter session, at which useful Papers had been read and discussed. The following officers were elected for the ensuing year:—

Branch President: Mr. O. G. Wilson.
Senior Vice-President: Mr. F. Swift.
Junior Vice-President: Mr. G. O. Stanley.
Representative to General Council: Mr. J. E. Mercer.
Representatives to Technical Council: Mr. J. E. Mercer and Mr. S. Leetch.
Reception Officer: Mr. J. G. Gould.
Auditors: Mr. H. Foster and Mr. J. H. D. Hobson.

Mr. J. G. Gould, Mr. H. Foster, and Mr. J. Ramsey, retiring members of the Branch Council, were re-elected, and Mr. S. Leetch was elected to fill the vacancy caused by Mr. Stanley's election as Vice-President. Mr. J. K. Smithson was re-elected Hon. Secretary.

Mr. O. G. Wilson, who was inducted to the chair at the conclusion of the formal business, proposed a vote of thanks to the retiring President, Mr. D. R. Kinnell.

Catalogue Received

Moulding Machines. The British Insulated Cable Company, Limited, Prescot, Lancs, have sent us a new folder which is primarily intended to emphasise the features of a new type of magnetic roll-over moulding machine, though some space is devoted to the well-known squeeze strip, downsand frame and double face boxless machines. A novel concept has been included as the base of the machine is part and parcel of a roller pathway conveyor system. This has every appearance of being a real energy saver.

The American Foundry Industry under the Defence Programme

(*Continued from page* 201.)

There are a number of experimental projects going forward to determine the advantages which the modern, improved irons might provide in shell manufacture, but as yet the emergency has not reached the point where cast shells are given much recognition by Ordnance Department experts. They do not feel that fragmentation characteristics are what they should be or that castings are entirely suitable for the job. However, should there be a change in this viewpoint, the larger mass production foundries are ideally suited to the manufacture of cast shells by the millions.

The Packard Motor Company expects to take four thousand of its current working force of ten thousand men and transfer them to the Rolls-Royce aircraft engineering and manufacturing plant now being erected. The Chrysler Corporation is also building a new tank arsenal which is expected to be in production in about a year, and the Ford Motor Company is erecting a vast structure for building Pratt and Whitney aircraft engines.

In conclusion, the entire foundry industry is bending every effort to co-operate with the entire activity and to fill its proper place as a source of vital construction parts demanded by practically every phase of the programme. There seems little reason to doubt that it will be successful in achieving its goal and, in the future, stand revealed as one of the most important links in the entire production chain. It is now doing, and will continue to do, its part.

Random Shots

Whilst delving into the history of Czecho-Slovakia recently, "Marksman" has come across an interesting weapon of war which must surely rank as the direct ancestor of the modern armoured car. There was much religious upheaval in that part of Europe during the fifteenth century, a state of affairs which led to actual fighting between the upholders of the Papal influence in the church and the Protestant followers of John Hus. A renowned leader of the Hussites was one John Zizka, who formed what he called his "invincible army." This army was supplied with "wagon-forts," which consisted of the ordinary wagons in use at the time covered and entirely protected with steel. A model is still to be seen in the Hussite Museum at Tabor, in Czecho-Slovakia. Incidentally, a little habit which seemed to meet with much favour in those times in Bohemia was that of throwing one's enemies out of the Town Hall windows. This delightful little occupation was known by the innocent sounding name of "Defenestration," and it is certainly a point worth remembering if one is lucky enough to catch any unpleasant visitor in one's bedroom.

* * *

It is not generally appreciated that since the bombing of the Metropolis began last August, Londoners have spent the equivalent of nearly two months in a state of "Alert." Northerners will no longer be able to accuse them of coming from the Sleepy South.

* * *

Chocolate Easter eggs are beginning to find their way into the tuck shops again. It is noticed, however, that they are mostly hollow, which seems to suggest that Mr. Bevin's speech of a fortnight ago has been quickly translated into action, and that Easter egg fillers are already switched over to a more urgent shell-filling task.

* * *

A man met a friend just coming out of the barber's shop.

"Hello," said he, "just been having a haircut?"

"No," replied the other, "I just dropped in for an estimate."

* * *

Very Random Shots or some tease s to occupy your mind whilst waiting for the canteen to open:—

(*a*) Which ex-Branch-President of the Institute of British Foundrymen is now an Army General?

(*b*) Which Branch Secretaries later became Presidents of the Institute?

(*c*) What are the names of the original members still appearing in the Institute's lists?

(*d*) What foundryman later became Foreign Secretary?

(*e*) Who were the last two men connected with the foundry industry to be awarded the Albert Medal of the Royal Society of Arts? And in what years?

The answers will be given next week, but no prize is offered; not even a war savings stamp.

* * *

The week's best crossword clue comes from "The Times."

Clue: Comomon.

Answer: Nothing in common.

"MARKSMAN."

MR. W. LINDSAY BURNS and Mr. Robert Hamilton, both of whom are connected with the National Steel Foundry of Leven, Fifeshire, have been co-opted on the local Air Training Corps to assist in its organisation and administration.

Melting and Casting Problems in the Production of High-Strength and Special-Duty Alloy Iron Castings

By A. E. McRAE SMITH, M.A.

(*Continued from page* 193.)

Graphite Distribution

It will be noted that the phosphorus content is given as very low, and this will be discussed later when dealing with the general effect of phosphorus in high-strength cast irons. Reverting to the question of graphite distribution and so-called graphite patterns in high-strength cast irons, it is sometimes observed that almost identical compositions can give a great diversity in physical properties. Whichever grade of high-strength cast iron is being produced, whether it be to meet 786 Grades II or III with pearlitic structures or for the routine production of higher strength grades of the acicular type, foundrymen fully experienced in the production of these classes of cast iron may encounter a cast which is very disappointing in its physical properties, although the composition is as expected and the processing is thought to be correct.

Almost invariably this will be found to be due to failure to get a random graphite arrangement, no matter what the matrix condition happens to be or even the size of the individual graphite flake. In other words, whether aiming at minimum tensile strengths of 18, 22, 25 and 30 tons per sq. in., if a dendritic graphite pattern is produced, no matter what the matrix structure is, the physical properties will decline very steeply.

It will be remembered that the first attempt to make high-strength cast iron of low carbon content (say 2.5 to 2.8 per cent.) in cupolas with comparatively high silicon contents was by the Emmel process. In this process little attempt was made to get random graphite structures. This led to many failures or discrepancies which can now be recognised as weak structures due to dendritic graphite patterns. Even in the Lanz hot-mould process, where the aim was to have a low-silicon cast iron with total carbon of 3.0 to 3.2 per cent. and a grey pearlitic structure, it was often noticed that, although the individual graphite flakes were much larger than in typical Emmel cast iron, the tensile strengths were often comparable.

Thus, in all types of high-strength cast irons, whether developed by special processing or produced by means of suitable alloy combinations, or both, it is essential to have random pattern graphite. In most cases this is ensured by correct processing, such as correctly applied late silicon or other forms of graphitising additions. This is given as a word of warning to the foundry metallurgist, and does not in any way affect the designer or user. If the latter calls for high-duty cast iron to any definite B.S. specification or any high specification he may care to designate, he will be amply covered by normal physical tests. The foundry metallurgist, on the other hand, can immediately check any tendency in this direction by taking simple micrographs, without waiting for physical test results.

Fig. 1.—Ni-Mo Cast Iron No. 14. Unetched. × 50 (approx.). Random Graphite.

Fig. 2.—Ni-Mo Cast Iron No. 14. Etched Nital. × 500 (approx.). Acicular Structure.

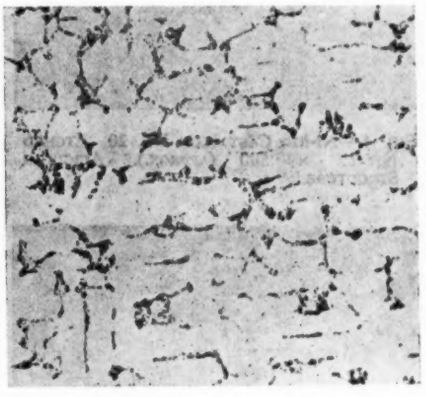

Fig. 3.—Ni-Mo Cast Iron No. 20. Unetched. × 50 (approx.). Dendritic Pattern Graphite.

Microstructure of the New Irons

As illustrating this phenomenon, Table II gives typical examples from an electric-furnace cast iron of the nickel-molybdenum acicular type.* The compositions of these two irons are almost identical, yet the physical properties show very great differences. It is only by examining the microstructure that these differences can be explained. Fig. 1 shows the unetched structure of the 1.2-in. dia. test-bar from melt No. 14, a typical example of random graphite. The etched structure of the same bar shows an acicular matrix (Fig. 2).

Figs. 3 and 4 are taken from a 1.2-in. dia. test-bar from melt No. 20. The acicular matrix as shown in Fig. 4 is exactly similar to Fig. 2, but Fig. 3 shows that the graphite in this melt exhibits dendritic pattern. Hence the much lower tensile strength. These are only given as examples, and it must be emphasised that exactly the same thing will occur in cupola-melted high-strength cast iron of pearlitic and acicular structure.

Figs. 5 and 6 show the graphite arrangement and acicular matrix of a cupola-melted nickel-chromium-molybdenum cast iron containing 3.05 per cent. total carbon. Although the total carbon content is high, yet a tensile strength of 28.5 tons per sq. in. was obtained on a 1.6-in. dia. test-bar as cast (machined to 0.798 in.). This micrograph was taken from a series of nickel-chromium-molybdenum acicular cast irons in daily production for hot heading dies, where structure, wear resistance and heat resistance are more important than strength. The small percentage of chromium is to help to stabilise the carbides under heat, and is not added to gain strength. In fact, it may detract from actual tensile figures. The microstructure shows rather large graphite of random arrangement, yet the tensile strength is much in excess of the highest B.S. specification. Over a recent period some 20 casts have given tensile strengths of 20.5 to 32.0 tons per sq. in. on the 1.6-in. dia. bar.

This shows that high-duty cast iron of this order is a thoroughly reliable commercial material and that its production does not require the installation of special plant. It can be produced in any ordinary cupola, provided the essential details are carefully observed and that contamination from other metal, as, for example, from premelting of later charges, is strictly prevented. This is a point about which some foundrymen are very careless, particularly where they imagine that a few extra pounds of coke after the last charge of special metal will

* Quoted from "Molybdenum in Grey Iron" Section V, published by Climax Molybdenum Company

Table II.—*Nickel-Molybdenum High-Strength Cast Irons (Electric Furnace) with Normal and Abnormal Graphite Structures.*

(By courtesy of the Climax Molybdenum Company.)

No.	Composition. Per cent.							Test-bar size. Ins.	Tensile strength. Tons per sq. in.	B.H.N.	Graphite.	Matrix.
	T.C.	C.C.	S.C.	Si.	Mn.	Ni.	Mo.					
14	2.50	0.61	1.89	2.73	0.98	1.02	1.03	1.2	36.7	321	Normal (random)	Acicular.
								2.0	34.2	302	Normal (random)	Acicular.
20	2.62	0.60	2.02	2.50	1.11	1.05	1.00	1.2	23.4	325	Abnormal (dendritic)	Acicular.
								2.0	26.5	293	Abnormal (dendritic)	Acicular.

D

be sufficient to avoid this ever-present risk. Where the amount of special metal being melted does not warrant a special "blow," then the cupola should be drained, the coke bed re-established and the cupola recharged. In addition, of course, the first one or two charges prior to the high-duty metal should be dealt with in the manner already described.

Of current importance to the foundry trade is the question of obtaining adequate supplies of low-phosphorus material for the production of high-strength cast iron. Normally, steel scrap, hematite pig-irons, Scotch pig-irons, refined pig-irons, together with ferro-silicon, ferro-manganese, etc., have been abundantly available and have satisfied all requirements when

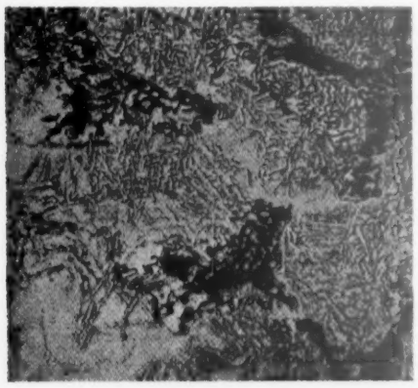

FIG. 4.—NI-MO CAST IRON NO. 20. ETCHED NITAL. × 500 (APPROX.). ACICULAR STRUCTURE.

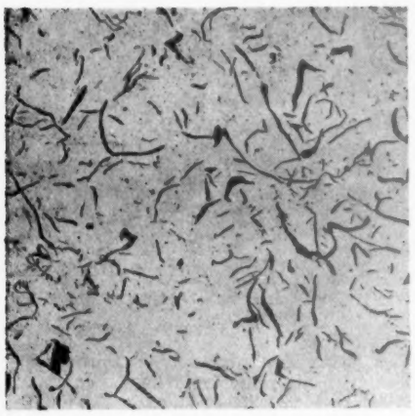

FIG. 5.—ACICULAR STRUCTURE OF NI-MO CAST IRON, SHOWING RANDOM GRAPHITE, AND CONTAINING T.C. 3.05; SI 1.86; MN 0.86; S 0.109; P 0.11; NI 2.17; CR 0.55; AND MO 0.65 PER CENT. MAX STRESS (ON 1.6 IN. DIA. BAR) 28.5 TONS PER SQ. IN. UNETCHED. × 60.

used in conjunction with normal alloying elements.

Influence of Phosphorus on High-Duty Irons

In the abnormal circumstances at present prevailing, with hematite and low-phosphorus pig-irons in short supply, research workers have turned their attention to the influence of phosphorus on the physical properties of high-duty cast irons. The question is how far use can be made of high-phosphorus pig-irons of the Derbyshire and Northamptonshire types with phosphorus contents ranging from 1.2 to 1.6 per cent. Since each 10 per cent. added to any mixing will give a phosphorus increment of 0.12 to 0.16 per cent., it is obvious that only a very small proportion could be used if the usually accepted low-phosphorus levels are to be adhered to.

The graphs illustrated in Figs. 7 and 8 give the results of work not previously published concerning a series of experimental casts which have recently been examined with a view to establishing the effect of phosphorus on tensile strength and shock resistance as measured by modified Izod single-blow impact tests.

The first series consisted of B.S.S. 786, Grade II type cast iron containing about 3.2 per cent. total carbon, 1.8 per cent. silicon and 1.5 per cent. nickel, with phosphorus contents of 0.03, 0.18, 0.23, 0.42, 0.55, 0.65 and 0.75 per cent. Fig. 8 shows the effect of increasing phosphorus on the mechanical properties. The tensile tests have been carried out on 0.875-in. and 1.2-in. dia. test-bars (as cast) and machined

FIG. 6.—AS FIG. 5 BUT ETCHED WITH 4 PER CENT. PICRIC ACID IN ALCOHOL, × 500, SHOWING ACICULAR STRUCTURE WITH MEDIUM GRAPHITE IN RANDOM ARRANGEMENT.

to 0.564 in. and 0.798 in. dia. respectively. The modified Izod single-blow impact test pieces were machined from the 1.2 in. dia. tensile bars to the dimensions given in Fig. 9.

The conclusion which may be deduced from these tests is that the effect of total carbon content is more important than the effect of phosphorus in the lower phosphorus ranges. Thus the points for the iron with 0.23 per cent. phosphorus fall below the curves for tensile strength and above for impact value, whereas the points for the iron with 0.42 per cent. phosphorus fall above the tensile strength curves and below the impact value curve. This is because, at 0.23 per cent. phosphorus, the total carbon content of the sample was too high (3.37 per cent.), and at 0.426 per cent. phosphorus was too low (2.96 per cent.). The general tendency is a slight increase in tensile strength initially, say up to 0.35 per cent., and a steady decrease after that. The impact value, on the other hand, shows a steady decline as phosphorus is increased.

The general conclusion may be deducted that up to 0.6 per cent. phosphorus, in this type of Grade II iron, there is little loss in tensile strength but a considerable reduction in impact value.

Fig. 8 gives graphs for a similar series of tests on a Grade III cast iron, having the general composition as follows: Total carbon, 2.9; silicon, 2.2; nickel, 1.5; and molybdenum, 0.5 per cent., with phosphorus 0.03, 0.03, 0.09, 0.20, 0.42, 0.63 per cent.

In a similar manner to the Grade II series,

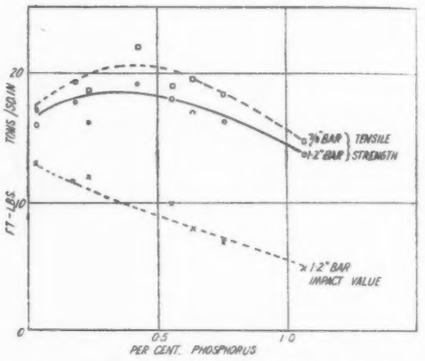

FIG. 7.—EFFECT OF PHOSPHORUS ON THE MECHANICAL PROPERTIES OF GRADE 2 (B.S.S.786) CAST IRON.

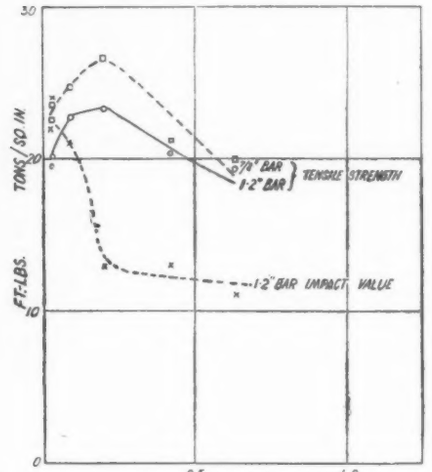

FIG. 8.—EFFECT OF PHOSPHORUS ON THE MECHANICAL PROPERTIES OF GRADE 3 (B.S.S.786) CAST IRON.

unintentional variations in the total carbon content have a greater effect on the tensile strength than phosphorus. If all the irons in the series had been at exactly the same total carbon level, the tensile strength curves would have been flatter, since at 0.2 per cent. phosphorus the total carbon content was low (2.8 per cent.), whereas the two higher phosphorus irons were rather high in total carbon (3.02 and 3.06 per cent.).

The tensile strength curve shows the same general tendency as in Grade II but the strength definitely falls away more rapidly, showing that a maximum phosphorus content of 0.4 per cent. is the most that could be tolerated in this grade of cast iron.

The sharp drop in impact value on passing from 0.1 to 0.2 per cent. phosphorus in nickel-molybdenum Grade III iron is almost certainly

(*Continued on page* 212.)

Cupola-Melted Blackheart Malleable Castings

SOME NECESSARY PRECAUTIONS

By V. N. WOOD

(*Continued from page* 188.)

Some Possible Failures after Annealing

After annealing, a good blackheart malleable iron has a fine black fracture, as shown in Fig. 4 (1). This fracture exhibits a silky sheen when turned at certain angles to the light. However, a small number of waster castings may be found after annealing treatment, due either to undesirable metal composition or to other causes. Distorted castings are those which have usually been subject to an annealing temperature high enough to render the material sufficiently plastic under heat to deform under their own weight, or the weight of other material directly above. Such castings usually have a coarse fracture, as shown in Fig. 4 (2).

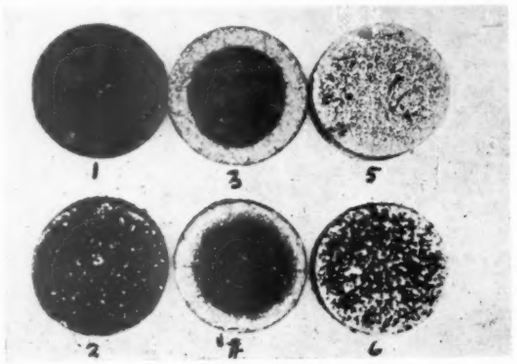

FIG. 4.—(1) GOOD FRACTURE; (2) COARSE FRACTURE SUCH AS OBTAINED BY TREATMENT AT HIGH TEMPERATURES; (3) METAL INCLINED TO BE GREY; (4) DECARBURISED; (5) PEARLITIC; (6) COARSE PEARLITIC-LOW SI AND C.

A white and hard fracture, after annealing, can be attributed to several causes, such as insufficient time at the annealing temperature, or too low an annealing temperature, due to either faulty pyrometric equipment or cold spots in a badly designed or controlled furnace. It may also be caused by very low silicon, alone or together with low carbon content, the lack of sufficient quantities of which, and especially in the case of silicon, greatly retards the rate of graphitisation. Manganese also affects the rate of annealing to some degree. It should be present a little in excess of that required to combine with the sulphur to form manganese sulphide; at the same time the excess should not be too great, otherwise under-annealing difficulties may be introduced due to the stabilising effect of manganese on carbide, especially during second-stage graphitisation and possibly due to the introduction of manganese carbide itself. The presence of chromium even in very small amounts, is capable of retarding graphitisation to such an extent that successful and complete annealing is virtually impossible.

A casting will sometimes be found which is weak and brittle, and examination of the fracture reveals a rather dull matte black interior, with a considerably lighter coloured lustreless edge, as is illustrated in Fig. 4 (3). A defective casting of this type is caused by metal which in the hard state was mottled with primary graphite. A microscopical examination will show large segregations of graphite in the centre of the casting, many of which follow the grain boundaries, whilst at the edge there will be a band of finer and more plentiful primary graphite. This structure is shown in Figs. 5 and 6. The primary graphite flakes greatly break up the continuity of the ferrite ground mass, causing a serious loss of strength and malleability.

Another defect, which at first sight appears to be similar to that of grey metal just referred to, is that of decarburisation, which is the burning or oxidising away of the surface carbon.

A closer examination of the fracture will show that the appearance of the inside of the casting is quite normal but the outside layer is rather lighter and somewhat steely in aspect as is shown in Fig. 4 (4). Decarburisation is always caused by the castings being subjected to oxidising conditions and the depth of decarburisation varies according to the severity of, and the time exposed to these conditions (Fig. 7). When they are particularly severe the carbon may be completely removed throughout castings of thin section, and in many such cases there is oxide penetration into the iron as shown in Fig. 8, especially at the grain boundaries at the edge of the casting. There are several causes of decarburisation—employment of air much in excess of that required for complete combustion of the fuel, and especially is this the case when pots are not airtight due to inefficient luting, or premature failure of the pot itself by the employment of one which has insufficient metal thickness to withstand the oxidising conditions. Decarburisation is generally associated with a considerable amount of scaling of the castings and after cleaning they may be appreciably "off size."

Incidentally the life of the annealing pots, which should allow for use several times, is considerably curtailed if constantly used in furnaces where oxidising conditions prevail. To minimise the occurrence of this furnace condition, and to correct, if possible, when present, it is a wise precaution to take gas analyses or check with a portable furnace atmosphere analyser. Castings, which by reason of their shape or small thickness, are packed in sand or other substances, may also suffer some decarburisation if the packing material contains any red oxide of iron, and is not completely burnt before use.

Cases sometimes occur where the metal has a tensile strength well above the average but only a small amount of ductility. Nodules of graphite or temper carbon may be plentiful and can be seen with the naked eye, giving a fine

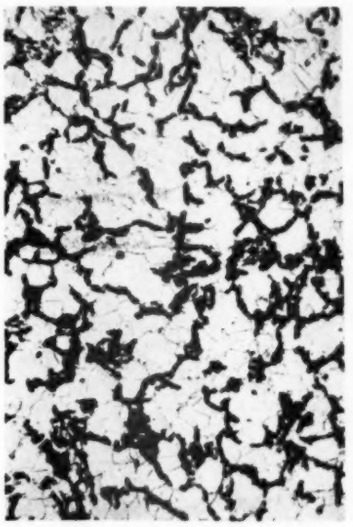

FIG. 6.—GREY METAL; CENTRE OF CASTING. × 100.

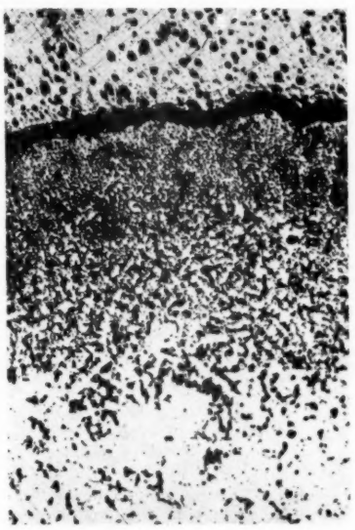

FIG. 5.—GREY METAL EDGE OF CASTING. UNETCHED. × 50.

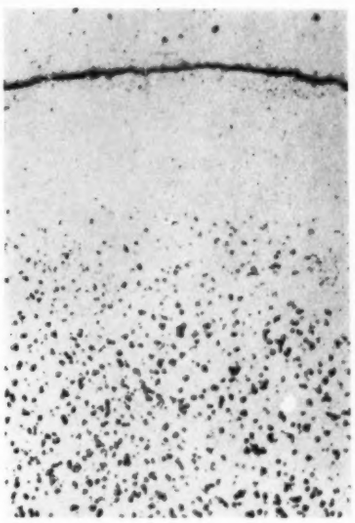

FIG. 7.—DECARBURISED CASTING. UNETCHED. × 25.

mottled appearance to the fracture and the material is not unduly hard. This type of material, shown in Fig. 4 (5), is known as pearlitic—the hardest constituent of the original white iron, namely, cementite—has not been wholly decomposed, and some of the pearlite which contains a quantity of the carbon in the combined form still persists. This is shown in Fig. 9. A common cause of this type of fracture after annealing is too rapid a cooling rate through the critical temperature range 730 to 700 deg. C. Also too high a manganese content along with low silicon and carbon may be responsible as is illustrated in Fig. 4 (6). Less frequently, exceptionally low manganese and silicon will also produce pearlitic malleable. Cases may occur where the fracture is not completely pearlitic, but the pearlite may be present

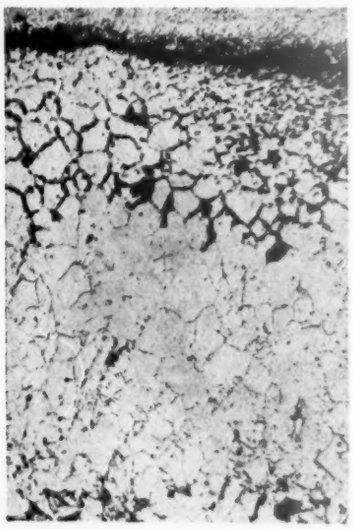

FIG. 8.—DECARBURISED METAL WITH OXIDE PENETRATION. ETCHED. × 100.

FIG. 9.—CASTING TOO QUICKLY COOLED AFTER ANNEALING. ETCHED. × 300.

as a white rim running at various depths near the edges of the castings and material of this description is often referred to as "picture frame" malleable, and the cause can often be traced to either very high or very low manganese.

Behaviour of Various Structures in Machining

Several of these divergences from the normal desired structure frequently give trouble when the castings are subjected to any machining operations. Theoretically, owing to the soft nature of blackheart malleable iron and the presence of fine, evenly-distributed temper carbon, machining should not introduce any difficulties; in fact, machinability is invariably excellent. If the metal is sound and correctly annealed, tool life should be long, and it should be possible to maintain high cutting-speeds. The presence of temper carbon in blackheart malleable iron assists machining both by breaking up the chip and by acting as a lubricant for the chip and tool.

However, with the case of under-annealed material and especially that in which the annealing is so imperfect as to retain some of the original hard cementite-pearlite structure of the white iron, very heavy tool loads are set up, and very early failure of the cutting edge results.

With material which has been decarburised to an appreciable extent owing to the tough character of the ferrite and absence of the lubricating properties of temper carbon, the cutting speed must be considerably reduced, otherwise a rough surface appears on the work, and it is very difficult to produce a fine smooth and clean thread. Ferrite, the product of decarburisation, tends to cut in rather long chips. As a result, the flutes in taps, dies or reamers may become clogged and prevent a clean cut. It is a common occurrence for the tool to bind in the work and fracture. Time and money is then lost in making and setting up new tools in the machine. It is therefore obvious that decarburisation is very objectionable in castings for machining, especially if its presence is unsuspected.

Conclusion

In conclusion, the foregoing survey covers the two main processes employed in the production of blackheart malleable iron castings, namely, melting and annealing of the iron. This branch of foundry work is perhaps one of the most specialised in the whole of the foundry industry, and the precautions involved to produce sound castings are numerous and varied, but if thoroughly understood and the processes are skilfully and technically controlled, it is possible to produce good and metallurgically sound material with almost unbroken regularity.

The author wishes to express his thanks to Crane, Limited, and their chief metallurgist, Mr. H. H. Shepherd, for permission to present this Paper.

(*Continued from next column.*)

This method of utilising cores proved quick and economical, effecting a substantial saving, as no assistance was necessary when setting the cores. A slight misplacement when entering the print does no damage, and the misplacement is easily rectified without lifting the core out of the mould. The cores forming the bottom of the mould afford protection from "scabbing," which might otherwise happen due to the searching action of the iron, which in this case is poured at high temperature, 10 cwts. of metal being required for this purpose.

Oil-Sand Cores Reduce Costs

By "W. G."

The use of slab cores cut to fit in certain parts of green-sand moulds is a time saver in that they ensure weak and "blind" sections of the mould practically foolproof. Where there is doubt of any part of the mould falling away when withdrawing the pattern from the sand, which would mean much time and patience rehabilitating, ramming a piece of oil-sand core up with the pattern gives excellent results. Also, at the place where a large volume of iron enters the mould, especially if it is required to pour the metal at high temperature, a slab of core introduced at that spot, where the metal hits the mould, will eliminate the risk of "scabbing." A recent example of the good results obtained by the use of these cores, "not marked on the drawing," is described in the following article.

A lathe bed pattern, shown in Fig. 1, was sent down to the foundry, marked "delivery urgent." The dimensions were 11 ft. 4 in. by 11 in. by 14 in. and 8 in. respectively as indicated. The thickness of metal, except at the bottom of the casting, was $\frac{5}{8}$ in. After an examination by the

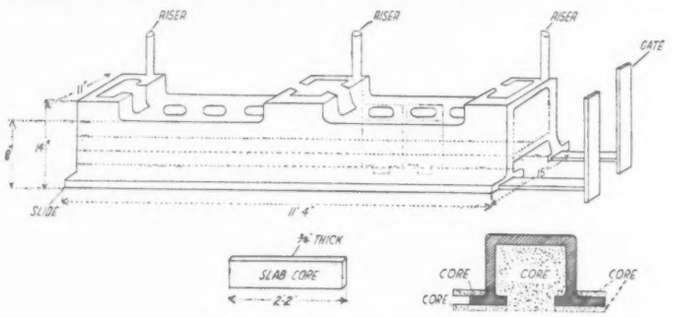

FIG. 1.—LATHE BED PATTERN.

moulder the pattern was bedded in the floor, and in the process of withdrawing it from the sand, the core print, not being provided with the least taper, pulled the mould up on each side of it, considerable time and patience being expended in making it good. Later, another snag was experienced when setting the cores. This operation required assistance, one astride the mould to lower the cores in by hand, while the other guided the core as it entered the print. The least diversion from the centre resulted in the core taking a part of the mould down with it into the print, the core having to be lifted out again and the disturbed part made good. As there were nine cores to be set in the mould, the results thus far were considered unsatisfactory, and slab cores were used for the remaining nineteen castings.

The method employed was to make a hard level bed, the iron bars, used as guides for the strickle being left in the floor until the order is completed. The pattern was then placed on the bed of hard sand, resting on its print, which in this case is 6½ in. wide, with a depth of ¾ in. Cores, 2 ft. 2 in. by 5 in. by ¾ in., were then laid under the pattern so that they contacted the print. The use of these cores abolishes the hammering down of the pattern in order to secure a solid mould, thus prolonging the life of the pattern and at the same time preventing any tendency to distortion. Ramming is then proceeded with up to the top of the slide, this being formed by lengths pinned on to the pattern, as they are easier to withdraw than if made in one piece. Cores are then laid on the slide, the lengths being taken out after withdrawal of the pattern.

(*Continued in previous column.*)

Jominy Test of Meehanite Metal

By A. C. DENISON (Fulton Foundry and Machine Company, Inc.)

As a routine laboratory test of steels that are to be hardened, the Jominy test has been helpful in determining the hardening characteristics of tool steels, thus enabling the selection of the correct steel both from a cost and operating standpoint. The test has been so successful that it was decided to carry out some tests on Meehanite metal to determine the best types for various applications which require heat-treated material.

Description of Test

The Jominy test is based on the principle of "end quenching," whereby a sample 1 in. in dia. and 2¼ in. long is quenched by striking it with a stream of water on the lower end when the specimen is set vertically. This will produce rapid cooling on the side near the lower end, with progressively slower rates of cooling at increasing distances measured along the side away from the lower end. Consequently, if the reaction rate is fast, high hardness will exist only near the lower end, but as the reaction rate of the material is slower, this high hardness will prevail at greater and greater distances away from this lower end against which the water is projected. As a matter of standardisation, the water is projected through a ½-in. pipe at a velocity which will raise the water as a fountain 2½ in. high. The specimen is held rigidly in the centre of this fountain ½ in. above the water pipe outlet. The temperature of the water is approximately 75 deg. F. The apparatus consists of a water tank rigged with a motor-driven pump with piping and valves for controlling the flow of water. Over the top of the tank is constructed a fixture for holding the specimen for quenching. Fig. 1 shows the machine built by the Fulton Foundry & Machine Company, Inc.

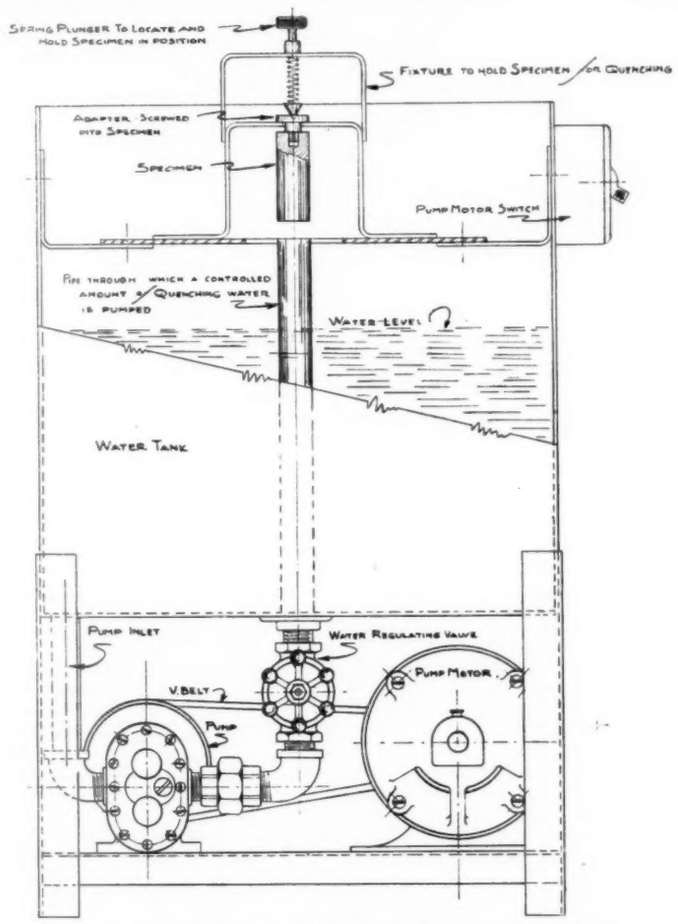

Fig. 1.—Jominy Testing Machine as built by the Fulton Foundry & Machine Company.

Preliminary Experiment

A few preliminary hardenability tests on a Jominy apparatus were carried out, and the results are shown in Fig. 2, with the object of determining the influence of manganese. These curves reveal a few interesting factors:—(1) Curves for specimens with 1.21 per cent. manganese and 0.85 per cent. manganese are similar, even though the silicon content of the former specimen is considerably lower than the other specimens previously thought to react favourably in the direction of hardenability. (2) Even though the silicon is high, the specimen with 1.60 per cent. manganese showed a greatly improved hardenability reaction. This is very significant, and should be remembered when considering other curves presented in this Paper.

In other researches the relation of cooling rates of bars of various diameters as compared to the cooling rate of the Jominy specimen at varying distances from the quenched lower end had been worked out by the investigators sponsoring these tests, and this creates a practical aspect to these Jominy curves. These curves are given in Fig. 3.

An interpretation or use of the curves shown in Figs. 2 and 3 would be in the case where one was dealing with a specimen 1 in. in dia. involving oil quenching. The curve of Fig. 3 shows the cooling rate of the specimen to be the same as ¾ in. from the quenched end of the Jominy test-bar; thus, by referring to the Jominy curve of Fig. 2, it is shown that ¾ in. from the end gives a hardness of over 50 Rockwell C. on all three samples, and the 1-in. piece will harden nicely. But, following through a 2-in. specimen, it is to be noted that the cooling equivalent is positioned at ¾ in. on oil quench, so that with the lower manganese specimens, the quench will produce only about 35 Rockwell C. hardness, while on the high 1.60 per cent. manganese specimen there is still over 50 Rockwell C. hardness. This shows a practical value to these curves for hardness cycle determination, because this same 2-in. specimen has a cooling equivalent on a water quench of ½ in. from the quenched end of the Jominy bar, which then would give satisfactory hardness on all three specimens with the three different manganese contents as shown in curves of Fig. 2. Thus there is a hardenability relation both from composition (with variations of manganese being of primary importance) and speed of quench, whether water or oil, and they are now placed upon an informative data basis.

At this point is seems desirable to point out that at the Fulton Foundry & Machine Company the management can on reflection find satisfaction in that their experiences with quenching and heat-treatment practices have been confirmed by the results given by these curves. This explains the reason why many trials had to be made as to time-quenching and to variation of tempering to get results which were thought strange at the time but which, it is now seen, were no doubt properly expected results had the equivalents disclosed by these tests and curves been known.

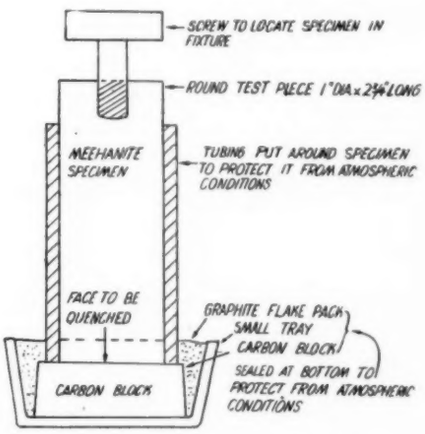
Screw to Locate Specimen in Fixture
Round Test Piece 1" Dia x 2¼" Long
Meehanite Specimen
Tubing Put Around Specimen to Protect it from Atmospheric Conditions
Face to be Quenched
Graphite Flake Pack
Small Tray
Carbon Block
Carbon Block
Sealed at Bottom to Protect from Atmospheric Conditions

Fig. 1A.—Arrangement of Test Piece in Electric Furnace.

Enlarged Research

With these preliminary results showing up so interestingly it was decided to enlarge the research and try to determine: (1) The effect of quenching temperature on hardenability; (2) effect of soaking-time sensitivity on hardenability; (3) effect of analytical variations on hardenability; (4) effect of Meehanite treatment on hardenability, and (5) anything else that might be disclosed while running these tests. For this work a number of special samples were cast and also eleven others were obtained from various Meehanite foundries.

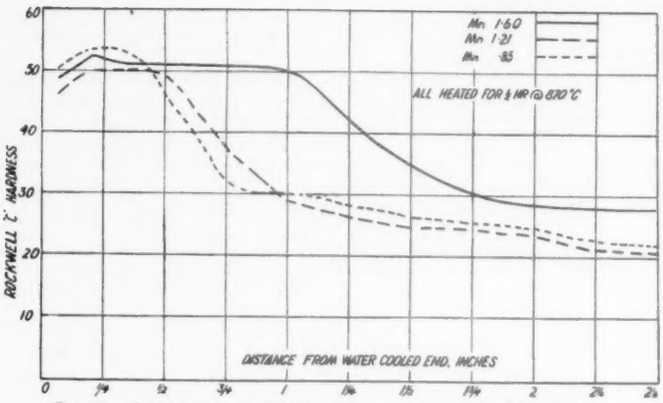

FIG. 2.—INFLUENCE OF MANGANESE AS SHOWN BY JOMINY TEST.

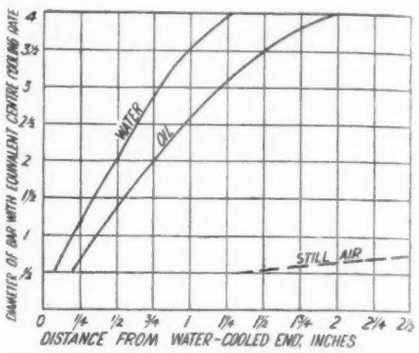

FIG. 3.—JOMINY HARDENABILITY SPECIMENS SHOWING EQUIVALENT COOLING VELOCITIES.

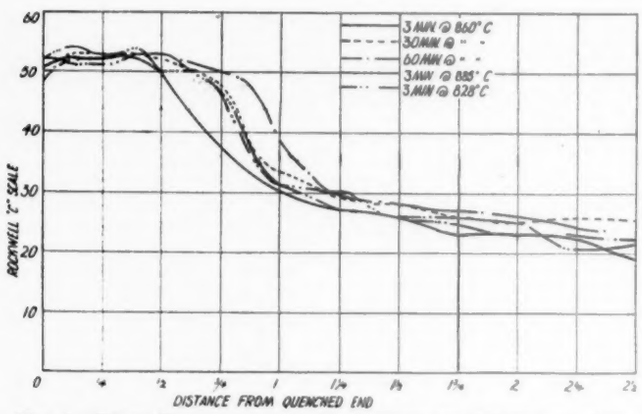

FIG. 4.—THESE TESTS INDICATE THAT REASONABLE SOAKING IS NOT DETRIMENTAL; HIGH MN NECESSITATES PROLONGED SOAK AND 860 DEG. C. IS A SUITABLE TEMPERATURE.

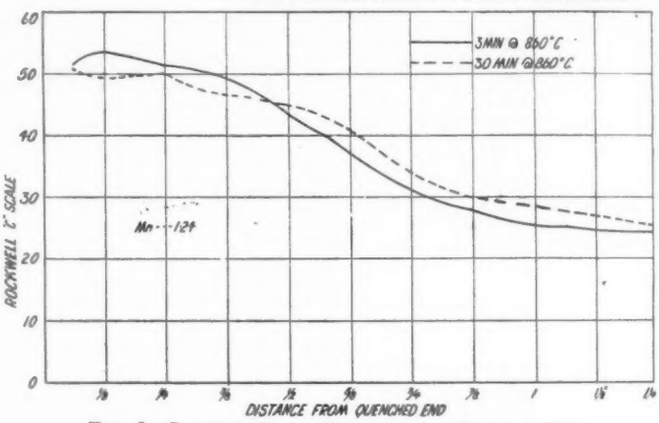

FIG. 5.—SHOWING SMALL INFLUENCE OF SOAKING TIME.

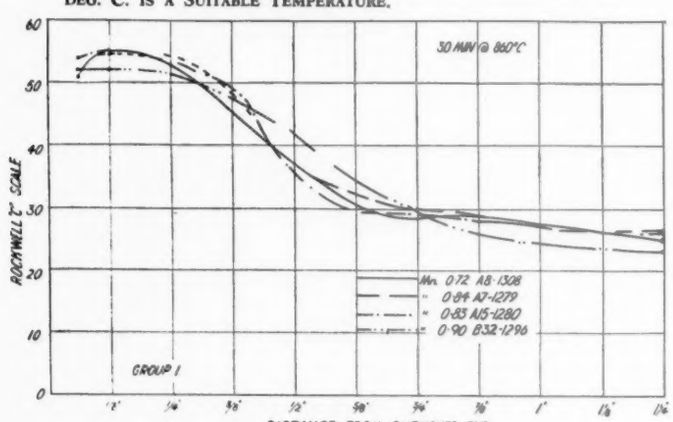

FIG. 6.

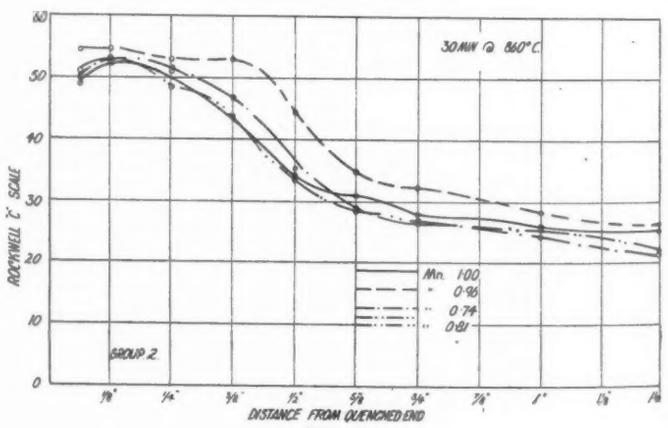

FIG. 7.

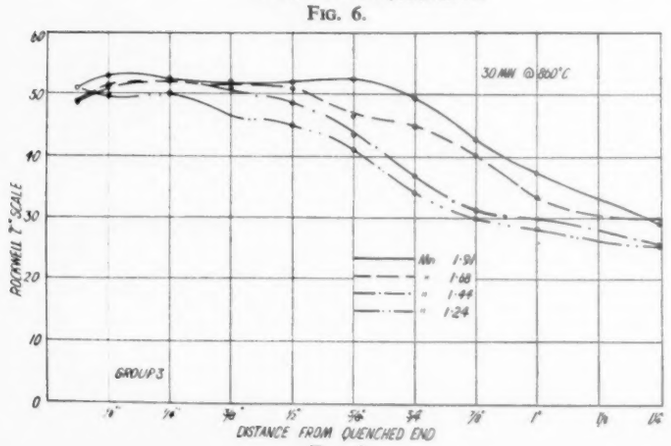

FIG. 8.

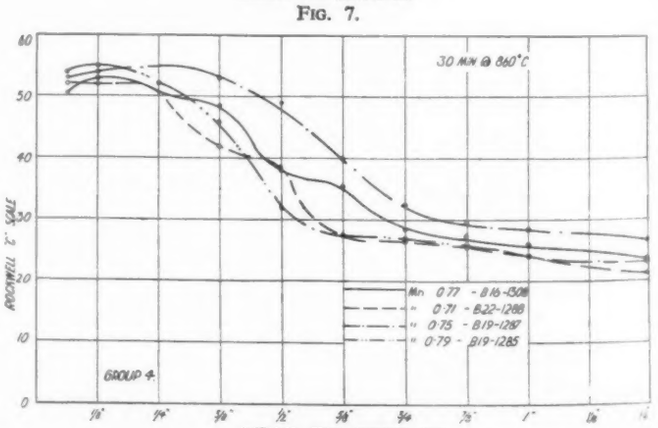

FIG. 9.

FIGS. 6 TO 9.—A GROUP OF 16 TESTS CARRYING CONSTANT MANGANESE CONTENTS, BUT OTHER FACTORS VARIABLE.

Effect of Quenching Temperature

A series of specimens were run to quench from 828, 860 and 885 deg. C., with soaking periods at temperatures varying from 3 mins. to 1 hr. were used at the intermediate 860 deg. C. temperature, all with the idea of getting some light on the importance of temperature and soaking-time as a factor in this research. The curves shown in Figs. 4 and 5 contain their own data.

Effect of Soaking-Time Sensitivity to Hardening

The curves shown in Fig. 5 on item 1 take in only a small practical range of temperature soak, and properly to obtain extended data would require a further research beyond the scope of this preliminary investigation. This may be done later. The work done, however, indicated that Meehanite suitable for heat-treatment is not unduly sensitive to breakdown on reasonable soaking periods, and not nearly as sensitive as was imagined. Therefore, for the balance of this investigation it was decided to use 30-min. soak periods at 860 deg. C. and where permissible to check this with 3-min. soak periods at the same temperature.

(2) Again observing the groups of curves No. 1 and No. 4 (Figs. 6 and 9), it is to be noted that some specimens are "GA" Meehanite and some are "GB" Meehanite, yet the Jominy hardenability curves are about the same. This would indicate that in general little, if any, difference exists in the hardenability properties of various types of Meehanite.

(3) Group No. 3 (Fig. 8) is a high-manganese series, and a quick glance shows that manganese is a potent element to delay the reaction rate and increase hardenability; also, that while increased percentages of manganese probably do continue to improve hardenability, yet a practical percentage seems to be about 1.50 per cent., which, on reference to the curve for cooling equivalents (shown earlier in this article), would give good hardenability on oil quench in about 1½-in. sections and on water quench 2-in. to 2½-in. sections. Likewise, when it is considered how very potent manganese is in delaying the reaction rate, it would seem that the chromium here had a minor effect and may not be so very effective in influencing hardenability, so that, if a good technique could be worked out to produce sound castings easily, manganese would be better to use than chromium to produce hardenability, because manganese produces tougher and more easily machinable castings than chromium, which even may tend to produce brittleness rather than toughness. In other words, it is thought that these curves favour manganese rather than chromium as a hardening alloy when considered from every standpoint. It is felt, however, that there is room for more investigation on the effect of chromium, especially for heavier-sectioned work where moderate percentages do not harm the pearlitic structure of Meehanite.

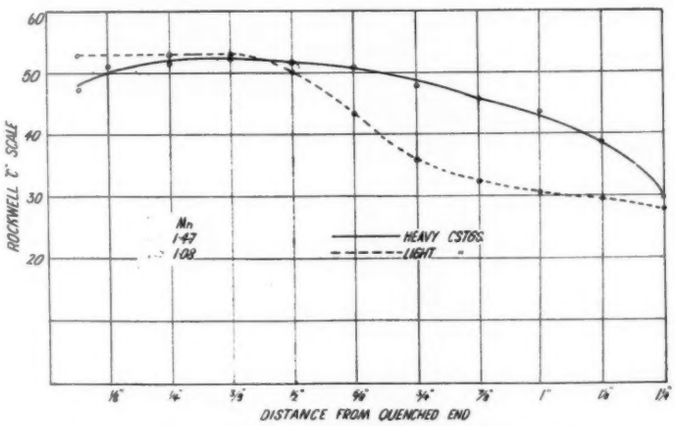

Fig. 10.—Curves for Light and Heavy Castings established as a Result of this Research.

Effect of Analytical Variations on Hardenability

As this investigation constitutes the first work of this kind on Meehanite, the author was unable completely to cover this subject, and intends to continue investigations along this line using new equipment and many new specimens. However, the specimens so far collected for this research had analytical variations, and some preliminary trends could be determined by grouping them and plotting Jominy curves and analysing these hardenability curves.

For this check the Jominy curves made on specimens soaked for 30 min. at 860 deg. C. are used, and as the tests were indicating that manganese was apparently the most controlling element in these specimens, four curves are grouped together in sets where the manganese percentage was closely the same. Sixteen specimens are covered by this series, shown in Figs. 6 to 9.

There is difficulty in drawing absolute and definite conclusions from these curves because in most cases more than one factor is influencing them, but some trends are fairly evident:—

(1) There is not much difference between the curves of group No. 1 (Fig. 6) and group No. 4 (Fig. 9). Also, in some instances there is not much difference in total carbon, manganese and Meehanite treatment. However, the silicon analysis varies quite widely from 1.14 to 1.68 per cent., which would indicate that at least in these lower ranges of silicon content silicon is not very reactive on the reaction rate to influence hardenability.

Two curves of Jominy tests are given in Fig. 10 on "A" Meehanite as made for lighter castings, and as alloyed with manganese for heavier castings.

Conclusions

No condensed summary of these investigations is practical as the conclusions run consecutively through this report. It is felt that this hardenability test has merit as a basic test showing the inherent quality of Meehanite, particularly in relation of one cast to another, and, as in the author's case, can lay the basis of improved metallurgical practice in the foundry.

The practicability of this test is thought to be well enough established for one to consider it a reliable tool for basic studies of new mixes that might be created by various alloy combinations that seem practical for future manufacturing procedure, and it is intended to continue research along this line.

Welding Cast Iron without Preheating

According to an article in "Oxy-Acetylene Tips" for the repair of fractured cast-iron pulleys or gears, the operator must control expansion and contraction stresses in the part during welding and immediately afterwards while the part is cooling. This is usually accomplished successfully by careful pre-heating, post-heating, and controlled cooling. However, emergencies may arise when such practices might be impossible, because of a lack of pre-heating facilities, or undesirable because the size of the part makes pre-heating uneconomical. The procedures described here have been used successfully by contract shops for the fusion welding of fractures in cast-iron pulleys and gears without preheating.

When a single spoke is fractured near the solid hub of a pulley, the procedure for controlling stresses is relatively simple. The fracture is first veed from both sides, preferably by chipping. Then a hack-saw cut is made in the same spoke at a point close to the rim. This cut, however, is not made completely through the spoke, but preferably from both broad sides of the spoke in such a manner as to leave a strip of uncut metal about ¼ in. thick across the centre section. The welding of the original fracture can then be carried on without special preheating. The additional opening, provided by the hack-saw cut, will permit expansion of the spoke while the fracture is being welded. The uncut section will keep the spoke in line.

After the welded fracture has cooled to room temperature, the hack-saw cut is welded closed. In order to obtain complete penetration, this portion of the spoke is first carefully veed by chipping. Because of the location of this weld, sufficient heat from the blowpipe flame will be carried over into the adjacent rim so that expansion will be taken care of by the flexing of the rim.

Multiple Fractures

When a combination of rim and spoke fractures exists, the order of welding is important, the outer fractures first and the inner ones next. The latter, however, should not be attempted until the former have completely cooled. When the spoke welds have cooled to room temperature, a jack is employed before proceeding with rim welds. The jack, placed between the spokes on either side of the rim fracture, is adjusted so as to force the fracture open approximately $\frac{1}{16}$ in. The clearance thus provided is sufficient to permit normal expansion of the rim during welding. After this final weld has been completed, the jack is removed and the weld is allowed to cool. It will be found that the resultant contraction will not cause a recurrence of the breakage.

With gears or pulleys of the split-hub type, a spoke broken adjacent to the hub can be repaired readily without pre-heating. In this case the fracture is prepared for welding by veeing in the usual manner. Then a shaft, or section of shaft, about $\frac{1}{16}$ in. smaller in diameter than the bore of the hub, is inserted through the hub. Bolts are then applied and tightened until the split-hub fits tightly around the shaft. As a result of this, the portion of the broken spoke adjacent to the hub will be drawn away from the balance of the spoke and the fracture will be opened sufficiently to take care of expansion caused by the heat of the welding. After the welding operation has been completed, pressure, previously applied to the split hub, is released by removing the hub bolts. This completes the repair, and the part is allowed to cool without danger of breakage due to subsequent contraction stresses.

Permanent Moulds for Producing Non-Ferrous Castings

EAST MIDLANDS DISCUSSION

In our issue of March 6, we published an excellent article on this subject by Mr. Frank Hudson. When it was presented to the East Midlands Branch of the Institute of British Foundrymen, it was highly appreciated as is indicated by the discussion which followed and of which the following is an extract.

Rate of Pouring

MR. R. H. BUCKLAND, who presided in the absence of Mr. S. E. Dawson through illness, opened the discussion by drawing attention to the physical property figures given by chilled castings which he said in comparison with sand cast results were really astounding, and these facts indicated that a founder must know the peculiarities of the metal he was using before he should decide to introduce permanent moulds into the foundry. There was one point on which Mr. Hudson might elaborate, and that was in connection with the rate of pouring, on the life of the mould. It would appear that the more constant the temperature of the mould, the longer its life, and therefore the rate of pouring the moulds must be of considerable importance.

MR. HUDSON, in reply, said providing a reasonable attempt was made to control the temperature of a cast-iron mould a considerable life was obtained. If a large number of castings were available, the simplest way of controlling mould temperature was to ensure that sufficient moulds are available to take all the metal from one particlar heat. By the time the next heat was ready the moulds will have cooled down normally in air to a safe limit. The need for the control of mould temperature in the case of refractory moulds was, of course, not so important.

Object of Permanent Moulds

MR. DUNLEAVY asked whether a permanent mould or a long-life moulding only was used as a means of producing high-quality castings or was it a means of increasing production? How 150 castings could be produced from one permanent mould in one heat and maintain the heat of the mould at 200 to 250 deg. throughout the pouring of these castings was from personal experience, a difficult proposition. This experience, however, had been confined to producing castings from one permanent mould only, and he would like to ascertain how many moulds would be necessary to produce, say, 50 handwheel castings. With annually changing design this reacted unfavourably in the application of permanent moulds.

A personal problem was that non-ferrous castings were ordered to-day and it was expected they would either be "cast" the same day or at least the following day and delivered as fully machined castings from the machine shop the day after. This practice made the use of permanent moulds an impossibility. Had Mr. Hudson any experience in the direction of producing aluminium bronze castings in the form of chilled bars for billets, and had he successfully solved the problem of eliminating the formation of dross when producing such castings normally? He finally congratulated Mr. Hudson on the design of the dry sand insert in the permanent mould for the production of non-ferrous valve castings, to permit the normal metal shrinkage.

MR. HUDSON replied that he had attempted to give the advantages and disadvantages of permanent moulds in their application to the production of non-ferrous alloys and suggested that each individual foundry would have to satisfy itself how this type of mould could best be applied to its own requirements. One type of foundry may find it an advantage to use the permanent mould in the production of high-duty castings whilst another may use it to increase production.

Cooling Arrangements

No doubt a metal mould would increase in temperature when the castings were poured, but there are several methods by which the temperature of the mould could be controlled, such as for example by air-blast or water spray. The refractory type of mould with its lower thermal conductivity could, of course, be allowed to reach higher temperatures.

Permanent moulds could be used to advantage in the production of castings such as hand wheels because it was unlikely that any particular metal would be specified and a wide range of non-ferrous alloys was available. Every advantage should be taken of this and it would be easily possible to produce 50 castings per day from two moulds, increasing to 100 per day after practice. It would, of course, not be wise to select gunmetal or bronze for hand wheels as contraction difficulties would be nearly unsurmountable. There should, however, be little trouble in utilising either aluminium or manganese bronze.

The production of chill-cast aluminium bronze billets is not a difficult job. The author gave a Paper on this subject published in THE FOUNDRY TRADE JOURNAL (February 2, 1933, page 86), which fully covers the matter and the recent book on "Aluminium Bronze," obtainable free from the Copper Development Association, is also worthy of reference. Bottom-poured chill moulds should be used or top pouring by the Durville method. Dross is avoided by the absence of turbulence during pouring and is assisted by the use of a special flux (Albral, etc.) which removes alumina during melting. In castings of complicated design the formation of oxide can be minimised by filling the mould with carbon-dioxide or nitrogen and casting from a bottom-pouring ladle through a tube filled with one or other of the gases mentioned.

Bearing Bushes

MR. BUTTERS said there were two aspects which call for explanation. Since showing the slide giving the resultant strength of chilled and sand cast castings, also the illustration of castings suitable in design for permanent mould casting, it would appear these castings could run themselves, as they seem to be "moulders' dreams." One casting produced in quantities of 100,000 annually was a phosphor bronze bearing bush, of 2 in. diameter by 1¼ in. long, 1 in. cored hole, and cast as complete bush. Could this be produced cheaply by permanent mould method, because there was a pip on the side of the casting to prevent it revolving when assembled. Could the lecturer say how many moulds would be required and some suggestion as to the most suitable method of design. At the present time castings were produced 18 per box, and production time was 3 mins. per box. Would permanent mould production show a saving on the present method of production, and would it be essential to use an oil-sand core to produce this cored hole when using a permanent mould.

MR. HUDSON, in reply, said that general practice to-day was for phosphor bronze bushes to be produced from chill cast solid or cored sticks rather than from individual castings. Apart from the foundry, this method in the majority of cases facilitates operations in the machine shop. Might it not be possible for Mr. Butters to adopt a similar technique, which would conceivably simplify production and make the use of permanent moulds a practical proposition?

For the production of castings in this manner a cast-iron, top-poured chill mould would be required in three parts, consisting of two sides and a bottom. A print for the core would be located in the bottom mould portion, whilst the top of the core would be held by a cross-bar. Oil-sand or loam cores can be used providing they are stiffened by robust wire or core bar. The use of a rotary core-machine for oil-sand core production is useful, as this will turn out a cylindrical core with a hole down the centre to take the wire after drying.

Regarding the application of the data given in this Paper, it is for the foundry to decide by what method they could best be applied. Many of the examples shown might constitute "moulders' dreams," but nevertheless they are made in large numbers, and accordingly it is well worth while considering alternative methods of production, apart from making them in sand.

Porosity in Age-Hardened Alloys

MR. GLADWELL asked whether the lecturer could give further information as to the use of sodium silicate as used for mould dressing? He was interested in the production of the centrifugal bars, and would like more information regarding size and shape. With reference to porosity in age-hardened metal, was this defect present with non age-hardening alloys. Is it an advantage to pour quickly or slowly when teeming non-ferrous alloys into permanent moulds.

MR. HUDSON, in reply, said that a more common name for sodium silicate was waterglass. Regarding the production of centrifugally cast bars, the method employed had been described in "Aircraft Production," July, 1940, page 211, and reference should be made to this for any further information required. Centre porosity in chill-cast bars can be present regardless of whether the alloy was of the age-hardening type or otherwise. The presence of porosity was, however, of particular importance in alloys, which must be subsequently heat-treated, as it obviously prevented maximum mechanical properties being developed.

It was not feasible to give any general comment about the pouring speeds required in permanent mould practice as so much depended upon the design of casting being made and the type of alloy used. In the majority of cases, however, fairly rapid pouring was required to facilitate foundry practice.

Size Limitations

MR. GOODWIN thought anyone could adopt permanent moulds for non-ferrous work of a fairly simple nature if there was a sufficient quantity ordered. What size moulds would be best adapted to this practice? Mr. Hudson mentioned a German process for producing a semi-permanent refractory mould. Had the author ever seen it in service, and could he give any figures regarding the length of life of the mould; if so, were these figures accurate, because, obviously, when the figures given could not be confirmed, they were useless?

MR. HUDSON said the size of moulds which could be best adapted for this practice would largely depend upon design. It should not, however, be imagined that these will always be of relatively small size. He saw no serious objection to making quite large castings successfully

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in permanent moulds if due consideration was given to the factors mentioned in the Paper. He could not give any more facts about the German process than were disclosed by the article in THE FOUNDRY TRADE JOURNAL, which stated that the length of life was between 20 and 30 castings, and he had no reason to doubt this information, because from personal experience refractory moulds had been known to produce this quantity of castings.

Age-Hardening Practice

MR. E. HOLLAND wrote that he was interested in the remarks relating to heat-treatment and age-hardening of certain non-ferrous alloys, and asked for comments on the following:—What was the temperature and duration of this treatment? What was the precise action of this treatment on the matrix of the metal? Was the age-hardening necessary, because the nickel was not finally in equilibrium and required stabilising, or was it merely an annealing action to normalise the effect of the chilling action of the mould?

MR. HUDSON wrote in reply that the heat-treatment to promote age-hardening in the case of the 5 per cent. nickel, 5 per cent. tin, 2 per cent. zinc bronze mentioned in the Paper was conducted in two stages. A solution treatment was first given consisting of reheating the castings at 760 deg. C. for about 2 hrs. and furnace-cooling down to 550 deg. C., and then quenching in water. This was followed by a low temperature hardening treatment, comprising reheating between 320 to 350 deg. C. for 5 hrs. and again quenching in water.

The precise action of this treatment on the structure of the metal cannot as yet be fully explained by the knowledge available, but it was not due to any segregational effects of nickel. After age-hardening, a definite structural change occurred which could be clearly observed under the microscope, introducing a third constituent, and it was due to this that the enhanced mechanical properties were obtained.

Vote of Thanks

MR. H. J. BECK, in proposing a vote of thanks, said that the application of permanent mould would be studied with interest by all concerned.

MR. G. L. HARBACH, in seconding, said he had listened with interest to the lecture, and would no doubt take advantage of Mr. Hudson's offer to reply to further questions by correspondence after the Paper had been published.

The vote of thanks was carried with applause, and Mr. Hudson suitably replied.

(*Continued from column* 3.)

successfully using the cupola as the melting unit. This, of course, is coupled closely with good foundry practice, and much could be said about branches of this technique, such as the study of self-feeding methods, methods of running castings, and use of denseners to control solidification, etc.; but that is beyond the scope of the present Paper. It will suffice to draw attention to the fact that high-duty cast irons are usually associated with applications which call for high perfection of finish and complete soundness of the metal structure throughout. In a great many cases the application will be for "machined all over" castings and castings which require to be completely pressure-tight under exacting conditions. Thus the foundry technique, although not calling for anything very different from that required in the production of good-class engineering castings, must be of an order that will take care of the above conditions.

Determination of Molybdenum in Steel

A comprehensive experimental study of the comparative reliability of various methods for determining the percentage of molybdenum in steel, and tests of the most suitable analytical procedures, are described in Report No. 140 of the Chemikerausschuss of the Verein deutscher Eisenhüttenleute published in a recent issue of the "Archiv für das Eisenhüttenwesen." The work was undertaken by a committee under the direction of P. KLINGER, who makes the report. The methods studied were the following:—

I.—Gravimetric analysis, consisting of precipitation of the Mo as sulphide with and without the use of pressure; (*a*) in acid solution; (*b*) in ammoniacal sulphosalt solutions and acidifying, final estimation by ignition to trioxide, reduction with hydrogen to disulphide, and reprecipitation as lead molybdate; (*c*) first precipitation in acid solution, followed by a second precipitation in alkaline solution, *i.e.*, a combined acid-alkali method.

II.—Volumetric analysis: (A) Titration with potassium permanganate after either (*a*) extraction with caustic soda, titration after reduction with zinc; or (*b*) precipitation with hydrogen sulphide, titration after reduction with zinc; or (*c*) precipitation with hydrogen sulphide, titration after reduction with zinc in Jones reduction apparatus; or (*d*) precipitation with hydrogen sulphide, titration after reduction with zinc amalgam.—(B) Titration with ferric chloride after reduction with titanium trichloride.—(C) Titration with methylene blue after reduction with zinc.

III.—Colorimetric methods: (A) Colour reaction with potassium thiocyanate on reduction with stannous chloride, after extraction with (*a*) ether or (*b*) caustic soda.—(B) Colour reaction with phenyl hydrazine.—(C) Colour reaction with potassium xanthogenate.

IV.—Potentiometric methods, with adaptations for plain Mo steels, W-free steels, and W and Co steels: (A) Reductometric method with stannous chloride.—(B) Oxidimetric method with potassium chromate, after preliminary reduction with zinc and chromous chloride.—(C) Reductometric estimation with titanium trichloride.

V.—Miscellaneous methods, such as the photometric, spectro-analytical, polarographic and polarometric.

Gravimetric Methods

Examination of the gravimetric methods indicated that precipitation under pressure is not imperative, although there is a slight increase in the accuracy of estimation. The gravimetric method to be recommended is that in which the Mo is precipitated with H_2S in acid solution followed by estimation as trioxide, as well as the Pb molybdate method after precipitation as trisulphide. Titration with permanganate also gives satisfactorily concordant results, but titration with ferric chloride and methylene blue proved unsatisfactory. Colorimetric methods using thiocyanate and stannous chloride or phenyl hydrazine gave good results, but the xanthogenate method was not sufficiently accurate. A study of the effect of copper, tungsten, vanadium, chromium, nickel, cobalt and tin when also present in the alloy, on the accuracy of estimation, showed that in the gravimetric methods, except the molybdate methods, the analytical procedure requires modification if copper is present, while the other elements have no adverse effect except when precipitating in alkaline solution. Very good agreement in the check tests was obtained with the potentiometric methods; great care must be exercised in the reductometric methods using stannous chloride. The photometric methods are useful and can be recommended for rapid estimations.

Melting and Casting Problems in the Production of High-Strength and Special-Duty Alloy Iron Castings

(*Continued from page* 204.)

due to the substitution of pearlite for shock-resisting acicular structure. In the case of pearlitic Grade III irons (without molybdenum) there is no reason to suppose that such a sharp change in impact strength would occur, though the shock resistance of the low-phosphorus pearlitic iron would no doubt be considerably below that of the acicular nickel-molybdenum type. The best phosphorus content for the acicular type would appear to be 0.1 per cent., giving a satisfactory compromise between tensile strength and impact value.

This work is still in progress and from a recent study of commercially-produced cupola cast irons of acicular structure this low phosphorus limit may be increased if the nickel and molybdenum contents are also increased.

Probably owing to the method of manufacture and raw materials being used to get the range of phosphorus contents without having recourse to ferro-phosphorus additions, the general tensile strength level is low in both series, but this does not detract from their value in showing the effect of phosphorus on the

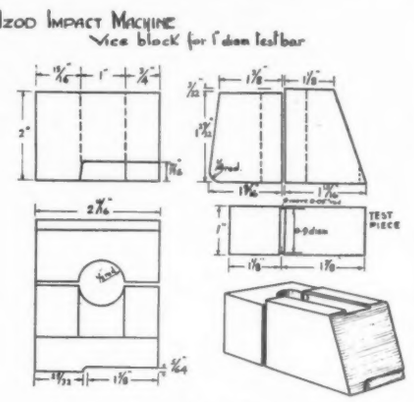

FIG. 9.—DESIGN OF IMPACT TESTING MACHINE USED.

physical properties, provided due allowance is made for unintentional total carbon variations.

From the above it can be deduced that for Grade II iron, up to 30 or even 40 per cent. high-phosphorus pig-iron may be used in conjunction with steel scrap and/or refined pig-iron with very low phosphorus content.

Overcoming the Difficulty

For Grade III irons this would have to be limited to about 20 per cent. of the charge, but in the acicular-structure cast irons, the state of present knowledge indicates an upper limit of about 10 per cent. However, if ample supplies of steel scrap are available, synthetic pig-iron could be produced first and remelted as part of high steel-mix charges, so that each ton of phosphoric pig-iron when melted with steel scrap and ferro-alloys might produce 5 to 20 times its own weight of high-strength cast iron by this means.

From the practical point of view, the above requires some qualifications. Even in Grade II irons it may be advantageous to limit the phosphorus content to perhaps 0.3 to 0.4 per cent. in complicated castings liable to exhibit liquid shrinkage porosity troubles.

In conclusion, this Paper has been intended primarily to show that really high-strength alloy cast irons can be produced regularly and

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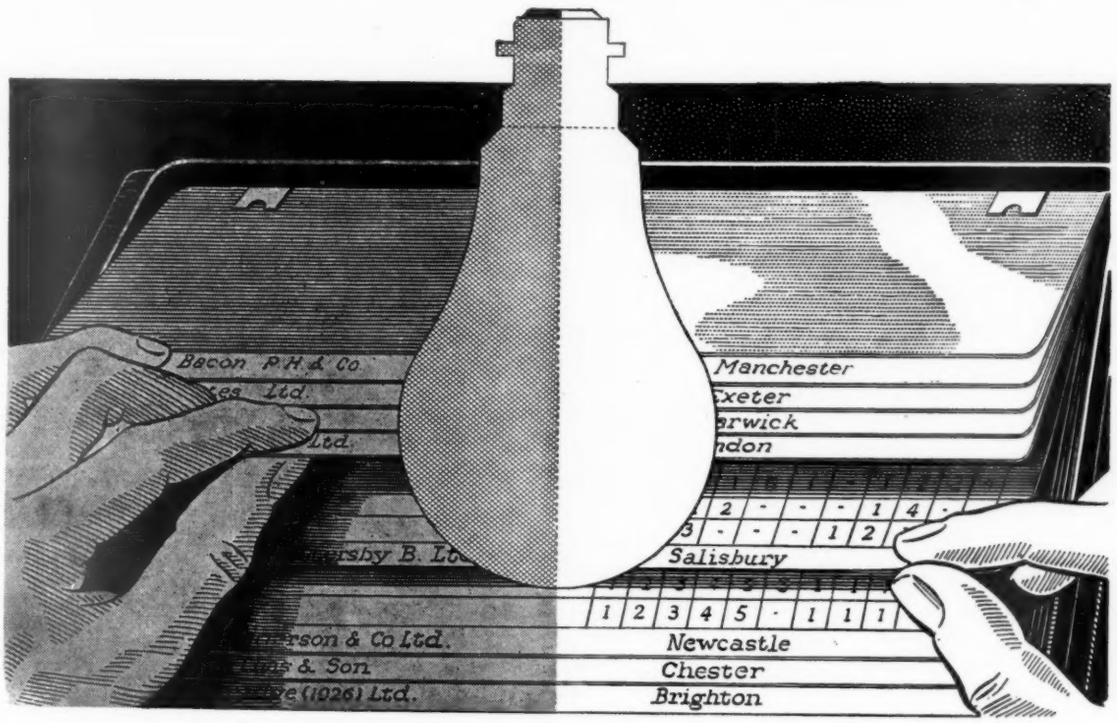

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Molybdenum Cast Steels*

The potential advantages to be derived from molybdenum additions to cast steel may be summarised as follow:—

(1) Fewer cooling cracks.
(2) Ability to develop high strength, without resorting to liquid quenching.
(3) Practical freedom from temper brittleness.
(4) Excellent impact strength.
(5) High strength at elevated temperatures.
(6) Dependable and uniform response to heat treatment.
(7) Good welding properties.
(8) Good machinability.

TABLE I.—*Properties of Carbon Molybdenum Cast Steels.*

Physical properties.	Tempered at 593 deg. C.	Tempered at 648 deg. C.
T.S., tons per sq. in. ..	40 to 42.4	35.7 to 40
Y.P., tons per sq. in. ..	20.5 to 31.2	24.5 to 29
E. per cent. on 2 in. ..	20 to 22	21 to 23
R.A., per cent.	55 to 60	58 to 63
B.H.N.	196 to 212	187 to 202
Izod imp., ft.-lb.	30 to 40	40 to 50

It is reported that the presence of molybdenum decreases the tendency of steel castings to crack on cooling. This desirable result is logically explained by the recognised ability of molybdenum to impart sluggishness to the transformation reactions, thereby reducing the rate of volume change in the critical range.

Machinability is invariably a primary consideration in the production shop and is often an item of considerable importance in the foundry. Shop reports indicate that cast molybdenum steels machine at relatively high Brinell hardness, with little or no tendency to tear under a cutting tool when proper tool feeds and lathe speeds are employed. A fine, smooth finish is readily produced with proper practice.

TABLE III.—*Properties of C. Mo. Steel at Elevated Temperatures. "Alloys of Iron and Molybdenum" (Gregg).*

Testing temp., deg. C.	T.S. tons per sq. in.	Y.P. tons per sq. in.	E. per cent. on 2 in.	R.A. Per cent.
15	29.0	17.0	21.0	43.0
100	28.1	16.5	12.0	38.2
200	36.2	10.1	12.8	37.8
300	33.9	15.6	18.8	42.2
400	26.8	15.2	18.5	58.6
500	20.5	14.7	17.7	63.6

Molybdenum intensifies the hardenability of cast steels, whether the addition is made to plain carbon or alloy compositions. This property may be a deciding factor in selecting a composition for castings where the shape, size and other considerations make liquid quenching inadvisable, or even impossible.

Cast steels can be alloyed with molybdenum in such amounts as to develop practical immunity to temper brittleness. High impact resistance is also characteristic of molybdenum cast steels.

* Compiled from data issued by the Climax Molybdenum Company of Europe Limited.

In wrought molybdenum steels, the ability of molybdenum steels to retain their strength at high temperatures is well known. Strength at high temperatures is largely responsible for the use of molybdenum cast steels for turbine parts, oil refinery equipment and similar elevated temperature applications.

Carbon-Molybdenum Cast Steels

These steels are a logical choice for valves, flanges, pump bodies, turbine housings and comparable applications where high strength at elevated temperatures is a primary consideration. Carbon-molybdenum steels may also replace carbon steels for such purposes as locomotive and machine parts subjected to shock or fatigue, and other applications in which the use of highly alloyed and heat treated parts is not practical.

Carbon-molybdenum cast steels in the carbon range commonly recommended for the above applications do not harden appreciably when air cooled, maximum hardness as welded being approximately 275 Brinell. Stress relieving after welding results in further reduction of hardness. These advantages, coupled with elevated temperature strength and relatively low cost, make carbon-molybdenum steels desirable and economical for moderately high temperature service.

Table I shows the average physical properties to be expected from the addition of 0.50 per cent. molybdenum to carbon cast steel of 0.25 to 0.30 per cent. carbon after normalising at 926 deg. C. and comparing at 593 and 648 deg. C.

TABLE II.—*Properties of C. Mo. Steels.*

Steel No.	C. Per cent.	Si. Per cent.	Mn. Per cent.	Mo. Per cent.	T.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent. on 2 in.	R.A. Per cent.
1	0.24	0.32	0.63	0.50	32.1	20.9	31.5	61.6
2	0.25	0.39	0.67	0.67	37.0	25.7	27.5	51.1
3	0.25	0.31	0.56	0.72	33.0	21.8	29.0	57.7
4	0.26	0.35	0.67	0.60	35.7	23.4	28.0	51.0
5	0.28	0.43	0.64	0.64	34.9	24.5	28.0	49.0
6	0.29	0.39	0.65	0.62	36.9	25.2	26.0	51.0

Table II gives the physical properties of several commercially-produced carbon-molybdenum steels. The test coupons were normalised from 940 to 954 deg. C. and tempered at 650 to 677 deg. C.

Properties at Elevated Temperature

Table III shows the quick tensile properties on an annealed carbon-molybdenum steel containing carbon 0.22, manganese 0.59, and molybdenum 0.32 per cent.

Book Review

The Sampling and Chemical Analysis of Cast Ferrous Metals: 3rd edition. Revised and enlarged by E. Taylor Austin, F.I.C. Published by the British Cast Iron Research Association, 21, St. Paul's Square, Birmingham, 3. Price 15s. net post free.

This work, originally published in 1929, has been out of print for some time and the third edition, re-written and greatly enlarged, is now issued in response to demand, in spite of difficulties due to wartime conditions.

It represents the most comprehensive collection of methods available at the present time for the sampling and chemical examination of cast ferrous metals, excluding steel, though the majority of the methods are applicable to this material. It covers the determination of all the elements commonly found in white and grey cast iron, pig-iron and malleable cast iron. A completely new section dealing with the

(*Continued in next column.*)

(*Continued from previous column.*)

examination of ferro-alloys has been added in the new edition.

Many of the procedures described in the earlier editions have undergone considerable modification and much new material covering recent analytical developments, has been incorporated in the text. Alternative methods are given in many instances and their comparative accuracy and limitations are critically discussed. The basic chemical principles underlying each procedure are separately treated in order to assist the reader's understanding of any particular process.

General laboratory technique is described and recommended analytical tolerances are given and notes are included on the care and maintenance of platinum apparatus.

Institute of Metals

At the annual general meeting of the Institute of Metals, held in London on March 14, a short Presidential Address was delivered by Lieut.-Colonel the Hon. R. M. Preston, D.S.O. At the outset he said there was one thought that had been in his mind for some years, and to which he would like, very briefly, to direct attention. He began by making two quotations from the address delivered by the Past-President, the late Mr. Barclay, at the annual general meeting in March, 1936. Mr. Barclay then said: "The founders (of our Institute) were men of foresight, and not the least of the many evidences of this is found in the original conception of our body as an organisation which should include not only 'scientific metallurgists' and 'manufacturers of non-ferrous metals,' but also 'engineers and users.' It is an important function of the Institute to bring these classes together, and their co-operation would be essential in dealing with problems which had to be solved in the future." And again: "The sequence of their industry was threefold: (*a*) the primary producer; (*b*) the manufacturing metallurgist, and (*c*) the user, *i.e.*, the maker of ultimate products."

These two quotations, said the speaker, summarised admirably the original aims of the Institute of Metals. It was to include not only scientific metallurgists and manufacturers, but also engineers and primary producers. He thought it would be agreed that, as regards the last named, the Institute had somewhat fallen short of the standard originally set by its founders. It was probable that, in talking of the primary producer, Mr. Barclay had chiefly in mind the refiner of the metals. But several processes intervened between the mining of the ore and the point when the refiner commenced his work, and it was to these processes and to those who carried them out—the mining engineers—that he (the speaker) would direct attention.

The extremely complex reactions which took place in the smelting of mineral ores, and in converter practice, have not yet received all the attention which they deserved. The removal of injurious impurities, in processes antecedent to final refining, offered a wide field for research which was beyond the compass of the practical miner. Speaking as a mining man, with some experience in management, but no more than a smattering of knowledge of the many intricate problems of non-ferrous metallurgy, the speaker said he was sure, from such experience and knowledge as he had gained, that some form of close co-operation between that Institute and the mining interests would be of great benefit to both parties. On the one hand it would enlarge the scope, the usefulness, and the influence of the Institute of Metals; on the other it would help in the solution of many problems which the practical man, intent on production, had little time to consider.

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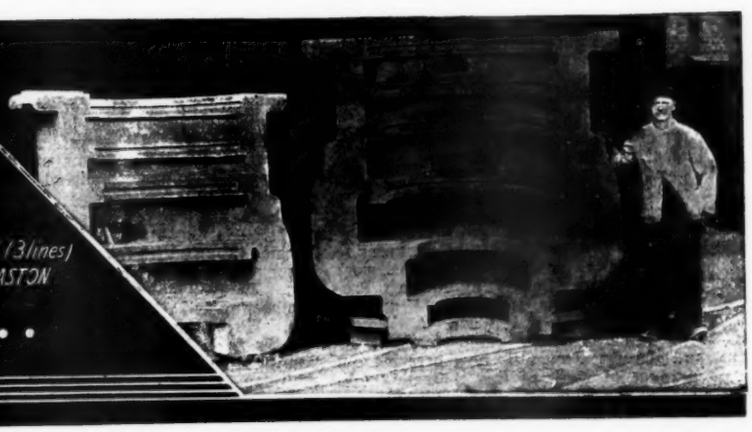

The Week's News in Brief

Trade Talk

WELDER'S BENCH SCREENS and other screens built up on a framework with non-detachable fabric, made to specification for a factory or a workshop, are not subject to the Purchase Tax.

THE COUNCIL of the Institute of Export has appointed a small panel with the object of placing the Institute's fullest consultative capacity at the disposal of the President of the Board of Trade.

THE DUTCH EAST INDIES GOVERNMENT is to finance the establishment of steel, aluminium and chemical works in the Dutch colonies, the first appropriation for this purpose being 10,000,000 guilders.

IT IS ANNOUNCED in Dublin that there has been a gratifying response to the appeal recently made by the Federation of Irish Manufacturers, Limited, for information as to available supplies in the country of derelict industrial plant.

BROKEN HILL PTY. COMPANY, LIMITED, is installing three large electric furnaces at Newcastle which will be primarily used for the manufacture of ferro-silicon and ferro-chrome. A small plant for the production of tungsten from Australian ores for the production of tool steels is already in operation at the Newcastle works.

THE BAUXITE INDUSTRY in British Guiana is steadily expanding with the heavy demand for aluminium; exports in the first half of 1940 were 240,000 tons, as against 476,000 tons in 1939 (12 months), 376,000 tons in 1938 and 301,000 tons in 1937. Further prospecting is being made, and shipping arrangements have recently been improved.

A DECREE OF THE MINISTRY OF COMMERCE for Bohemia and Moravia prohibits the establishment of new foundries, metal-working shops, fabricated-steel shops and sheet-metal works, during the current year, except with the express approval of the ministry. Existing plants must not increase their capacities, or plant reopened which has been closed for more than six months.

IN ORDER that the utmost possible benefit may be derived from United Kingdom exports and with a view to ensuring that the volume of exports is kept within the means of payment, an Order has been made by the Board of Trade which subjects to licensing control all goods exported from the United Kingdom to Brazil, Chile, Colombia and Peru. This Order came into force on March 6.

SIX NEW MEMBERS who have been appointed to the Industrial and Export Council are also to serve on the committee of the Council which will assist in the "telescoping" of industries. Their names are: Lord Portal, Mr. George Tomlinson, M.P., Sir Nigel Campbell, Mr. Charles Dukes, Mr. C. U. Peat, M.P., and Mr. M. Watkings. The following members of the Council are also members of the "telescoping" committee: Mr. F. D'Arcy Cooper, Mr. S. R. Beale, Lord Forres, Mr. M. Hodgson, and Sir Cecil Weir.

UNDER A BOARD OF TRADE ORDER which comes into force to-day, the exportation of aluminium hollow-ware is controlled to all destinations, but applications for export licences will not, normally, be entertained. Where stocks are held by persons registered under the Limitation of Supplies (Miscellaneous) Orders, the Ministry of Aircraft Production are prepared to purchase such stocks at cost. Persons wishing to dispose of their stocks on this basis should apply to the Aluminium Control, Ministry of Aircraft Production, Southam Road, Banbury.

THE REPORT of the Livesey Professor (Dr. D. T. A. Townend) on the work of the University of Leeds during the year 1939-40, states that during the Session a request was received from a Committee under the chairmanship of Prof. David and constituted to organise a University war effort, that an analytical laboratory should be set up in order to undertake metallurgical analysis and testing work for the Admiralty and Ministry of Aircraft Production, should this become necessary. A number of assistants were trained by Mr. A. Preece (Lecturer in Metallurgy) in rapid methods of analysis, and the Department is now carrying out a certain amount of work of this character. In another direction the workshop staff of the Department is helping as far as is possible in war production work.

Personal

SIR JOHN E. THORNYCROFT, K.B.E., has been elected an Honorary Life Member of the Institution of Mechanical Engineers, over which he presided in 1937.

MR. FREDERICK CRESSWELL PYMAN, who has been a member of the board of the Iron Trades Employers' Insurance Association, Limited, for 17 years, has been appointed vice-chairman to fill the vacancy created by the death of Mr. John Barr.

DR. THOMAS SWINDEN has been awarded the Bessemer Medal, the highest honour which the Iron and Steel Institute can bestow. This award will be highly appreciated by the foundry industry, where his contributions to metallurgy are widely esteemed; his practical support of its technical endeavours appreciated and his personal character admired. Dr. Swinden, who is a graduate of Sheffield University and a Mappin Medallist, is the director of the Central Research Laboratories of the United Steel Companies.

Wills

ROBINSON, C. H., a director and formerly general manager of the North British Locomotive Company, Limited	£13,380
NISBETT, G. H., of Huyton, Lancs, electrical engineer, late managing director of British Insulated Cables, Limited, chairman of Thomas Bolton & Sons, Limited, copper smelters and manufacturers, and other companies	£142,817

Obituary

WE REGRET to record the death by enemy action of Mr. S. G. Smith, the well-known Lancashire foundry expert, and an honorary life member of the Institute of British Foundrymen. A full appreciation of his career will be printed in our next issue.

A WELL-KNOWN Midland ironfounder, Mr. John James Howell, of 148, Birmingham Road, West Bromwich, died last week. Mr. Howell had, during his career, held positions with Belliss & Morcom, Limited, and Hunt Bros., Limited, and for the past fifteen years he had controlled the Birco Motor Cylinder Company, Limited.

MR. FRANCIS EDWIN (FRANK) BROWN, head of David Brown & Sons (Huddersfield), Limited, gear makers, has died at his home, Somerfield, Holmfirth, aged 67. Mr. Brown was associated for over 50 years with the firm, which was founded in 1860. Mr. Brown was a former president of Huddersfield Engineering Employers' Association. His son, Mr. David Brown, is the present managing director of the firm.

SERGEANT-PILOT SYDNEY LEONARD JAMES KNIGHT, R.A.F., of Walsall, was killed recently while on active service, as the result of a flying accident. Sergeant-Pilot Knight was a student at the Wednesbury Technical School and became a metallurgist and was with A. H. Mould & Sons, Limited, of Walsall, until the outbreak of war. He was also secretary of the Associate Section of the Staffordshire Iron and Steel Institute.

MR. ALEXANDER SMITH LORIMER, second son of the late Sir William Lorimer, the first chairman of the North British Locomotive Company, Limited, Glasgow, has died at the age of 63. Mr. Lorimer, who was a director of the company, had been associated with the locomotive industry all his working life. He served an apprenticeship in one of the constituent firms of the North British Company, and was appointed a director of the company in 1911.

MR. ALEXANDER CAMPBELL has died at the age of 71. He joined as an apprentice the Hunslet Engine Company, Limited, Leeds, of which his father was manager, and eventually became chairman. In 1930 he was appointed president of the Engineering and Allied Employers' National Federation. During the last war, as a colleague of the late Sir John McLaren, he developed the production of munitions in the Leeds area, and became chairman of Leeds Engineering Employers' Federation. He followed his father in becoming a member of the Council of Leeds University, and in 1928 received the degree of Hon.LL.D.

Reports and Dividends

Platt Bros. & Company (Holdings), Limited—Final dividend of 2½ per cent. on the 4½ per cent. preference shares.

Federated Foundries, Limited—A debit balance of £21,301 (against a credit of £24,181) is carried forward.

Thos. Firth & John Brown, Limited—Net profit for 1940, £390,822 (against £508,459 in 1939); final dividend of 6½ per cent., free of tax, making 12½ per cent., free of tax, on the ordinary shares (against 17½ per cent., tax free).

Vickers, Limited—Net profit for 1940, after providing for taxation, £1,119,120 (against £1,192,041 in 1939); to contingencies, £250,000; final ordinary dividend of 6 per cent., making 10 per cent. (same); carried forward, £651,821 (£480,188).

British Insulated Cables, Limited—Profit for 1940, £786,232 (£783,224); depreciation, £209,622; war contingencies, £100,000; final dividend on the ordinary shares of 10 per cent., plus a cash bonus of 5 per cent., making a total of 20 per cent. (same); carried forward, £488,699 (£488,305).

Millom & Askam Hematite Iron Company, Limited—Net profit for 1940, after charging £105,634 for taxation, £105,858 (against £122,393 for 1939); dividend of 10 per cent. on the ordinary shares (same); written off fixed assets, etc., £36,774; carried forward, £39,216 (against £26,737).

General Refractories, Limited—Trading profit of company and its U.K. subsidiaries for 1940, £189,436 (against £163,703); net profit after depreciation, taxation, etc., attributable to General Refractories, Limited, £41,607 (£50,482), of which £41,224 (£50,084) has been included in that company's accounts; dividend of 5 per cent. (same); to reserve, £4,000 (nil), in respect of the liability which may accrue under the War Damage Bill; carried forward, £73,473 (£54,936).

Lancashire Steel Corporation, Limited—Earnings for 1940 of the Corporation and its wholly-owned subsidiaries, £1,215,624 (against £989,301 for 1939), depreciation of fixed assets, £175,000; reserved for replacements, £25,000; taxation, £701,000, plus £40,000 further tax liability deducted from the balance brought in; to general reserve, £25,000; dividend of 7 per cent. on the "A" and "B" ordinary shares; carried forward, after preference dividends, £82,763.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Clay-Alumin, Limited, 3, Arundel Street, London, W.C.2—Capital, £500. Directors: E. Penn, A. H. Salmon, L. Yates, F. Nehammer, and C. W. Espensen.

Garside Machine Company, Limited, 41, York Street, Chorlton-on-Medlock, Manchester—Capital, £2,000. Manufacturers of washing and wringing machines, etc. Directors: J. Waxman, J. J. Lock, S. Maxwell, and H. G. Robson.

Contracts Open

London, E.C., April 7—Iron and steel; bolts and nuts, steam tubes, etc.; iron, brass, gunmetal and other castings, etc., for 12 months from June 1, for the Metropolitan Water Board. The Chief Engineer (Room 171), offices of the Board, New River Head, Rosebery Avenue, London, E.C.1.

Manchester, April 7—Iron castings, for the Cleansing Committee. Mr. Bertram B. Jones, director of public cleansing, Town Hall, Manchester, 2.

Redruth, April 2—Iron castings, galvanised water pipes and fittings for the year ending March 31, 1942, for the Camborne-Redruth Urban District Council. The Surveyor, 2, Station Hill, Redruth, Cornwall.

The "Arc Torch"

A new electric welding device, known as the "Arc Torch," is described in a recent issue of "Steel." The apparatus, it is said, greatly enlarges the scope of electric arc welding equipment, the arc torch giving an extremely hot, easily controlled flame whose chief characteristic is lack of pressure. Thus molten metal is not forced away, but can be flowed where wanted. It is particularly valuable for welding aluminium and its alloys, for welding and brazing cast iron, and for brazing all types of steel.

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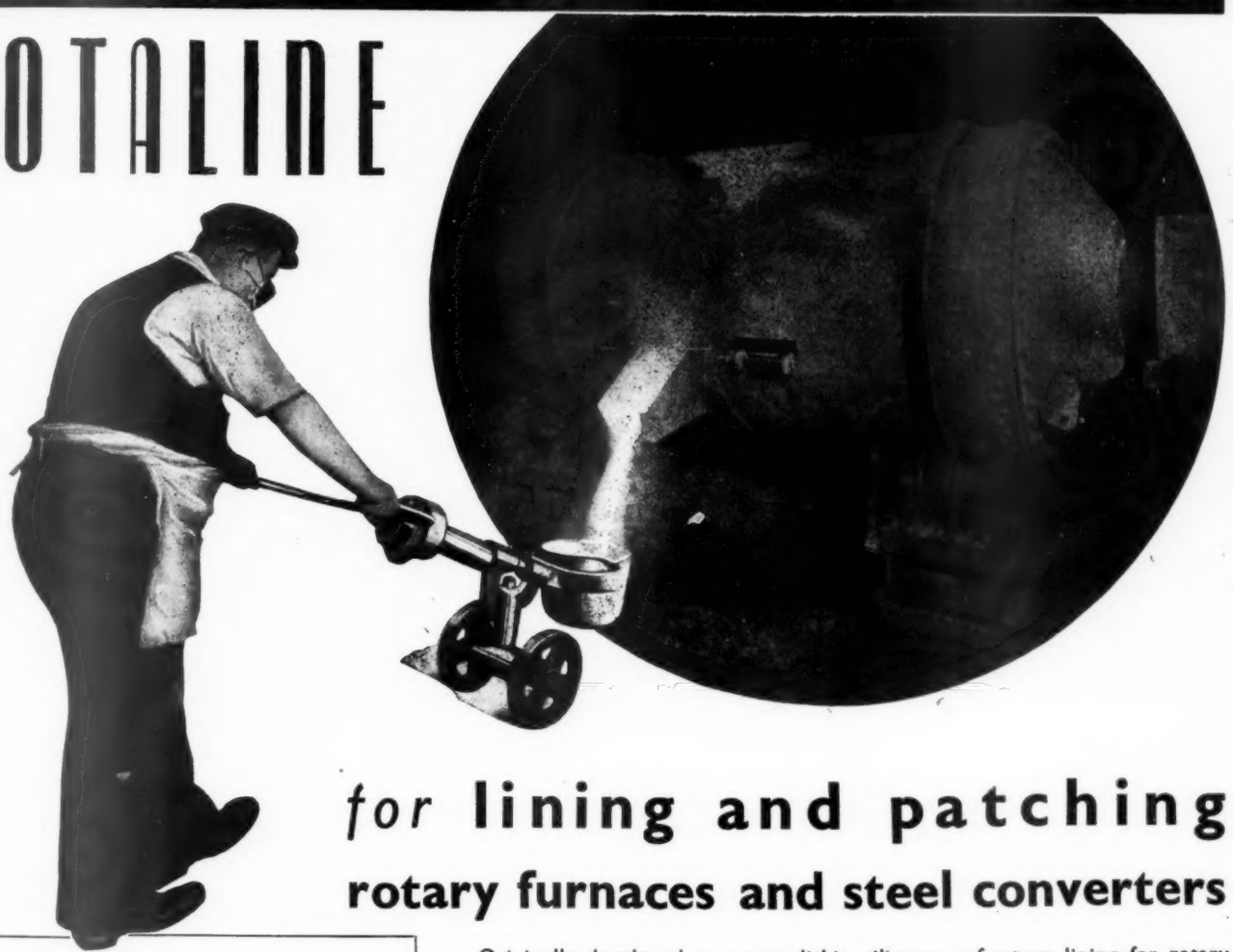

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Raw Material Markets

While heavy engineering foundries continue to be fully occupied on work of national importance, there is still much room for improvement in the light-castings trade, firms in this department being variably situated. Establishments which have been able to adapt their production facilities to meet Government requirements are naturally better placed for work than those still relying on the demands of ordinary buyers, chief of whom are builders. The latter have recently been placing orders for fairly substantial supplies of castings, but the volume of business forthcoming from the building and other consuming industries remains insufficient to enable the light foundries to operate on a full-time basis. Adequate supplies of iron for the light-castings trade are coming to hand, and the needs of the heavy engineers are fully, though less easily, met.

Pig-Iron

MIDDLESBROUGH—Midland blast furnaces are despatching adequate supplies of foundry iron to meet the current requirements of users in the Cleveland district, and a few consumers have been able to lay down small stocks. Fresh purchases can, of course, only be made by licence, but these are being granted quite freely in most instances. Many foundries are now making heavier demands for iron as a result of improved working conditions, and it seems likely that still heavier order-books will be reported in the near future. Demand for hematite remains insatiable, but, if anything, pressure for deliveries has been a little less insistent of late, due to some extent to consumers having altered their mixtures to meet present circumstances. However, in a large number of cases it is impossible to economise in the consumption of hematite, and essential needs are still very heavy. Local production continues to be supplemented by imported material, distribution of foreign iron being carried out by the Control authorities with the utmost care.

LANCASHIRE—Ordinary grades of foundry iron are in only moderate request by light-castings makers and jobbing foundries, and all demands are being met promptly. No relaxation is noticeable in the demand for iron for makers of machine-tool and other speciality castings, and substantial parcels are being regularly taken up by producers in this area. Hematite is required more freely than present deliveries permit, while some difficulty is experienced in obtaining specific grades of refined iron.

MIDLANDS—Blast furnaces in this district are being called upon to satisfy the foundry iron requirements of consumers outside the area, including Scotland. This they are able to do well, and deliveries of high-phosphorus iron are moving freely. In fact, small stocks are being accumulated by some buyers who have been permitted by the Control to lay down reserve supplies. This is very gratifying, as for some time past users had been compelled to operate on a hand-to-mouth basis, which at times caused inconvenience. The light foundry trade is not yet working to capacity, although makers are better placed than for a considerable time past, due to the acquisition of orders on Government account, together with a pronounced improvement in the requirements of ordinary users, especially builders. Heavy engineering establishments in the Midlands continue to work full time, work of national importance occupying their attention as it has done for a long time past. These concerns utilise low-phosphorus iron and hematite mostly, and supplies are less easy to obtain than in the case of high-phosphorus material. However, no concern is allowed to lose working time through absence of iron, and in many cases it has been possible for users to make alterations in their mixtures so that their reliance upon low-phosphorus iron and hematite could be reduced to a minimum.

SCOTLAND—Consumers of pig-iron here are endeavouring to obtain all the iron they can secure through the Control authorities; but supplies are not available except under licences, and these are being issued only to priority works in most instances. Heavy engineers are very actively engaged, replacement orders being readily available for these firms, but the position of the light-castings industry is still variable. Some of the latter have obtained a certain amount of work for Government departments, but orders through ordinary channels are not impressive, although demands from the building trade have improved. Iron for the steelworks is in great demand, and no reduction in consumption is likely; in fact, the reverse is more probable.

Coke

More than sufficient foundry coke continues to be forthcoming to meet current requirements, and a large number of buyers have taken the opportunity to put aside considerable tonnages against future needs, this being possible despite the absence of a firm forward quotation. Producers cover themselves against any change in prices by the inclusion of a rise-and-fall clause in all contracts. For delivery to Birmingham and Black Country stations, the current price of Durham best foundry coke is 61s. 6d. per ton.

Steel

Since the war commenced distribution of steel has been gradually restricted to an ever-narrowing class of consumer owing to the urgent demands made upon production by essential work, so that now little, or no, steel is available to users not directly engaged on Government contracts. Even so, it is necessary for the Control to allocate considerable tonnages of imported steel to make up the deficiency in home outputs. Production at home works, however, is very satisfactory, and outputs are being expanded when opportunity arises. Bookings for the second allocation period of the year are in progress, and it is certain that producers will have no difficulty in disposing of their full outputs up to the end of June.

Scrap

It has been decided to extend immediately the National Fixed and Demolition Scrap Survey to the 22 counties remaining to be covered. For some time past there has been a shortage of certain descriptions of scrap iron and steel, and it is to be hoped that the more rapid investigation into the potential scrap resources of the nation will produce additional tonnages at an early date. The collection of demolition scrap especially might well be speeded up, as much of this could be put to very good use immediately. It may become necessary to import scrap on a larger scale than at present if more material is not brought forward from home sources, although everything must be done to prevent the utilisation of further shipping space for such bulky cargo.

Metals

Tin—At their quarterly meeting in London on Thursday last the International Tin Committee decided to maintain the tin quota at the current level of 130 per cent. of the standard tonnages during the second half of the year. The output control agreement, which is due to expire at the end of this year, is to be extended for five years, subject to certain adjustments in the existing scheme. These decisions were discounted in market circles and were not followed by any sharp reactions in trading conditions. It was further recommended at the meeting that the Malayan and Netherlands East Indies standard tonnage allotments should be raised by a certain proportion, and that the Bolivian standard tonnage should be reduced, while an additional recommendation was that the new standard tonnages so evolved should be calculated on the basis of one year's output at the present permitted figure of 130 per cent. of existing standard tonnages. If this recommendation is adopted by the signatory governments, it will indicate a reduction in the Bolivian standard allotment to about 40,000 tons per annum, compared with the 46,000 tons now allotted to that country. As the current Bolivian output is believed to be around 38,000 tons a year, it is not expected that Bolivia would experience any real inconvenience if she accepted the revised allotment. Malaya's allotment would be increased from about 77,000 tons a year to around 88,000 tons and that of the Netherlands East Indies from about 39,000 tons to about 50,000.

The quota decision has been generally welcomed, meaning as it does that the mines can continue to produce to capacity. The American Metals Reserve Company will also be enabled to purchase tin over and above the extent of 75,000 tons, which was earlier believed to be the limit of the buying programme of that concern, which has been entrusted with the task of laying down stocks of tin for the use of the Government. Under the terms of the existing control of output agreement a decision to continue the scheme, or otherwise, had to be reached and suggested changes had to be proposed before the end of this month, and the outcome of the meeting last week is considered to be very satisfactory. The proposals must be accepted or rejected by the signatory governments during the ensuing six months, and it is felt that negotiations will be carried through rather more easily than was at one time thought would be the case.

According to a message from Singapore, the Government of the Federated Malay States has revised its policy with regard to tin prospecting. There has recently been some agitation in the Federal and State Councils and the Government has now issued the following communiqué:—"Applications for prospecting licences, mining leases and conversion to mining title of agricultural land and reserves will be considered from any person or company on merits." In the past the policy of the F.M.S. Government has been to restrict applications for licences to holders of assessments or to bona-fide prospectors with proved records approved by the Federal Secretary. No fresh assessment under the tin control scheme will be issued as a result of the revised policy.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £272 10s. to £272 15s.; Friday, £273 to £273 5s.; Monday, £272 5s. to £272 10s.; Tuesday, £273 5s. to £273 10s.; Wednesday, £273 5s. to £273 10s.

Three Months—Thursday, £270 15s. to £271; Friday, £270 15s. to £271; Monday, £270 to £270 10s.; Tuesday, £270 10s. to £271; Wednesday, £270 5s. to £270 15s.

Copper—Good supplies of copper continue to be despatched to consumers operating on Government contracts, and no priority user of the metal is permitted to be inconvenienced by lack of supplies. This satisfactory state of affairs does not indicate that a surplus of copper exists in the United Kingdom, however, and the Control authorities are scrutinising applications for fresh supplies as carefully as ever, non-essential buyers standing little chance of acquiring their full requirements. In the United States, heavy tonnages are being taken up. It is reported from New York that the American Government is taking over 20,000 tons of copper held in that country on French account, and it is now believed that very little copper in this category remains in America.

Spelter—Fresh urgent demands for this metal are regularly coming to hand, and distribution of spelter is being made carefully. In fact, it has become necessary to curtail certain zinc-consuming operations on account of the intense demand for Government needs. Brass mills, galvanisers and die-casters, especially, are taking up very large tonnages, these sections being favoured with a considerable volume of important work. There is a sustained demand for both g.o.b. spelter and high-grade metal. With the production of motor cars, other than vehicles for use of the military and for export, not permitted in the United Kingdom, the use of zinc alloy die-castings in this industry is now at a minimum. The utilisation of these castings in the United States is likely to be considerably reduced in the future, motor-car manufacturers there having been requested by the National Defence Commission to conserve essential defence materials. In response to this appeal one large firm has announced that it will reduce the consumption of zinc in strictly ornamental car parts.

Lead—Ample supplies of this metal are coming forward to meet all requirements. While Government demands tend to expand steadily, other consumers are still able to obtain sufficient to satisfy their needs. It is probable that there will be some tightening in the supply position during the next few months.